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ICE FORMATION IN LAKES AND RIVERS

OLAF DEVIK

Meeting of the Society, 15 May 1944

IN a paper in the *Geofysiske Publikasjoner*, vol. IX, No. 1, 1932, I have treated quantitatively the different factors in the process of heat exchange at a water surface in open air. By the formulae and tables given in that paper, it would be possible to calculate the net loss of heat from a water surface under given meteorological conditions. Corresponding tables also give the net loss from ice surfaces or from snow surfaces. I will not enter into detail, but very briefly quote some figures to give an idea of the loss of heat and the corresponding growth of ice under some typical meteorological conditions. When I escaped from Norway in March 1943 I was not able to bring any papers with me, and consequently the results from investigations in recent years have had to be quoted in the present paper only from memory. For the same reason no complete list of my publications on this matter in recent years could be included.

Consider first the sunlight and the daylight radiation in northern latitudes in winter. At a low sun-altitude, say 5–10°, a water surface will reflect a considerable part of the sun rays. A fraction will enter the water and be gradually absorbed, the transmitted radiation being practically all absorbed in the bottom of the lake or river. The unit of heat is the calorie, the amount of heat which is needed to raise the temperature of 1 gramme of water by 1° C. At a sun-altitude of 5°, 1 square centimetre of water surface will receive only 0·6 calorie per square centimetre per hour. This will be only 0·5 per cent. of the amount of sun-radiation reaching the atmosphere.

In these conditions and with clear sky the diffused daylight from all parts of the sky will give a greater input, namely, 3 cal./cm.^{2}/hour. If the sky is clouded, the diffused daylight absorbed in a water surface will be less, but still represent 1 cal./cm.^{2}/hour, which is more than the direct radiation would give at the low sun-altitude considered.

These figures of heat gained are small compared with heat losses in the winter. But when the sun's altitude increases, the incoming radiation, direct and diffused, will contribute more and more to the heat absorbed; and in the summer the relation will be the other way round, the heat given will exceed the heat lost.

Confining ourselves in this paper however to the conditions in mid-winter, say at Christmas time, we then pass to the loss of heat by infra-red radiation and choose as a representative condition an air temperature of −10° C. With a clear sky the heat radiation from a water surface at 0° C. will be 13·8 cal./cm.²/hour. In the case of a clouded sky, the amount is much less, 4·9 cal./cm.²/hour.

It is a very important fact that practically all non-metallic surfaces will absorb almost completely the infra-red radiation of the type radiated from objects of moderate temperature. Thus the radiation from a hot kettle will be absorbed completely in the surface layer of water which, on the other hand, is transparent to ordinary visible rays of light. From the infra-red point of view, water is a "black body." This is still more the case with snow. The perfect "white" surface of snow relates only to visible light: to infra-red radiation of the type we mentioned snow is a perfect "black body." This means that infra-red radiation falling upon a water surface or a snow surface will be completely absorbed in the uppermost layers, in a very thin sheet of some hundredths of a millimetre thick. On the other hand, the same layer will emit infra-red radiation of the same type to the atmosphere.

The next process we have to consider is the loss of heat by convection. This loss will be due to the difference in temperature between the water surface and the air above, but it will also be modified by the wind. Everybody knows that a vessel or a body is much more rapidly cooled down when a cold wind is blowing than when it is calm. To give the figures relating to a water surface: with an air temperature of −10° C. and calm, the heat loss by convection will be 2·8 cal./cm.²/hour. With a wind velocity of 5 metres per second, the loss will be 11·5 cal./cm.²/hour.

There is still one loss which we have not yet considered—that due to evaporation. The evaporation will depend first, upon the dryness of the air above the water surface or, more exactly, upon the vapour pressure, and secondly, upon the wind. With an air temperature of −10° C., a vapour pressure of 2·6 mm. of mercury, and calm air, the loss by evaporation from a water surface will be 1·7 cal./cm.²/hour, but if there is a wind of 5 metres per second, it will increase to 7·7 cal./cm.²/hour. It is an everyday experience when bathing in open air that the cooling caused by wind is very strong when the skin is still wet.

Next, if we add all the heat losses in water and subtract the gain of heat, the net heat loss under the first set of meteorological conditions, air temperature −10° C., vapour pressure 2·6 mm., wind velocity 0 m./sec., cloudiness 0, sun-altitude 5°, water temperature 0° C., will be 14·7; and in the second set, air temperature −10° C., vapour pressure 2·6 mm., wind velocity 5 m./sec., cloudiness 10 (overcast), sun-altitude 5°, water temperature 0° C., it will be 23·1 cal./cm.²/hour. These figures are equivalent to a production per hour of a sheet of ice of thickness 2·0 and 3·2 mm. respectively.

The growth of a sheet of ice

The analysis which we have briefly outlined in the preceding paragraph forms the basis for the calculation of the actual growth of ice on still water. We could simply apply the figures directly if the surface of the ice retained the temperature of o° C., and had the same physical properties as water with regard to heat exchange. The first supposition is however entirely wrong because the surface temperature of the ice will be the lower the thicker the ice, supposing the air temperature is low.

Fig. 1 is a diagram of the temperature distribution in an ice layer of growing

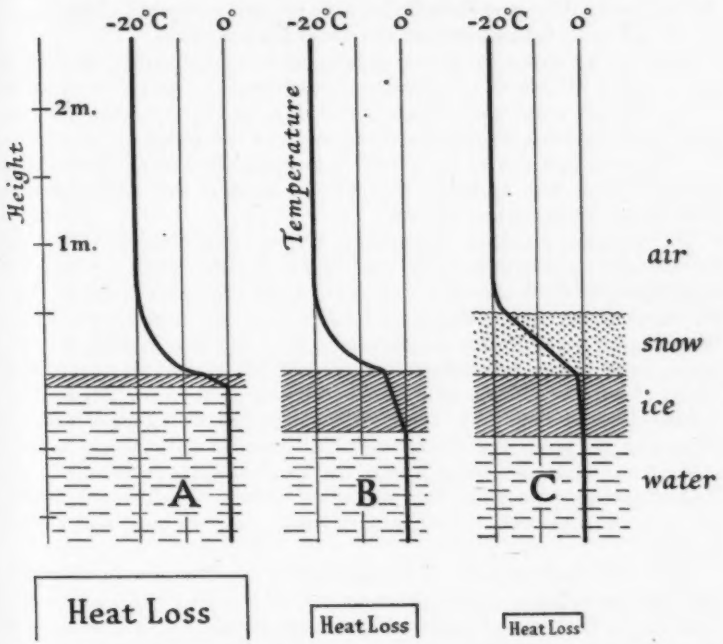


Fig. 1. Temperature distribution in A, water, thin ice, and air; B, water, thick ice, and air; C, water, thick ice, snow cover, and air

thickness. In A the sheet of ice is very thin and the temperature gradient is very steep. The loss of heat is correspondingly great and the ice-thickness will increase rapidly. In B the ice has attained considerable thickness, the temperature gradient in the ice is much smaller than in A, and the loss of heat is correspondingly less. In the third case, C, the ice layer is covered by a considerable layer of snow with the result that the temperature gradient in the ice is very small and the heat flow is correspondingly reduced. The gradient in the snow is considerable but the thermal conductivity is much smaller than in the ice. The net result is that the surface of the snow will have

a very low temperature, practically the same as that of the air. The resulting heat loss will be very small.

If we turn the diagram through 90° it will also represent the temperature distribution under winter conditions through the outside wall of a house of varying thickness and with an isolating layer. This may be of some interest when we are pondering on the insulating qualities of prefabricated houses.

Ice formation and supercooling of the water surface

The crystallization process does not start by itself. It requires starting nuclei, *i.e.* particles of solid matter which have already a crystalline structure. In open water these particles will always be present; it requires a high degree of precaution to clean water from all sorts of possible nuclei.

When an ice crystal has started growing upon a solid particle, the heat of solidification, 80 calories per gramme of water, must be carried away, which means that the temperature outside, or inside, the crystal surface must be lower than the temperature at the crystal surface itself, which is 0° C. Therefore the water in which an ice crystal is growing will generally have a temperature below zero or be supercooled. To measure this supercooling is however not always an easy matter.

We may use a precision thermometer with very fine divisions. But if the thermometer is brought from the cold air into the open water the bulb will immediately be covered by a thin sheet of ice and the measurement is spoilt, the thermometer only indicating the freezing point. In order to perform the measurement we must heat the bulb above 0° C. and then immerse it in the water. With proper precautions it is not difficult to observe supercooling effects of some hundredths of 1° C. The freezing point on the thermometer is best observed simply by covering the submerged thermometer with ice formed on the spot. The measurement will however only give an average of the temperature in a water layer of the same thickness as the size of the bulb. If we want to measure the temperature of the surface layer itself where the heat exchange with the air actually takes place we must adopt other methods.

During the winter of 1941–42 I performed a series of measurements with a Moll thermopile placed in a special mounting and provided with photographic recording of the potential delivered by the thermopile. Fig. 2 is a sketch of the arrangement. I used a Moll thermopile of the large type with 80 thermoelements placed within a receiving area of diameter 20 mm. The chief difficulties arise from the fact that the temperature will be very unevenly distributed in the space where the thermopile is to be placed: at the water surface the temperature will be near 0° C., but it will decrease rapidly with height, till the general air temperature is reached. Moreover this temperature distribution will change with every puff of wind. The thermopile is extremely sensitive to temperature differences in the adjoining metal housing and it is essential to reduce the temperature gradients in the material of the cone and the diaphragms of the free opening, and to keep all changes of these gradients slow.

Both requirements are met by using a casing with a great mass of good conducting material, preferably copper or brass, by machining the diaphragms

out of the material itself, and by using a motor ventilator to obtain evenly distributed temperature of the housing just before the measurements commence.

The thermopile being exposed to the radiation from the surface, the temperature of which is to be measured, will produce a voltage which is the greater, the greater the difference of temperature between the thermopile and the surface. In our case the water surface will have a temperature of nearly 0° C. while the air at the place of the thermopile casing will be much colder, for instance −15° C. We are however not interested in measuring this temperature difference, but in the changes which are due to changes of the

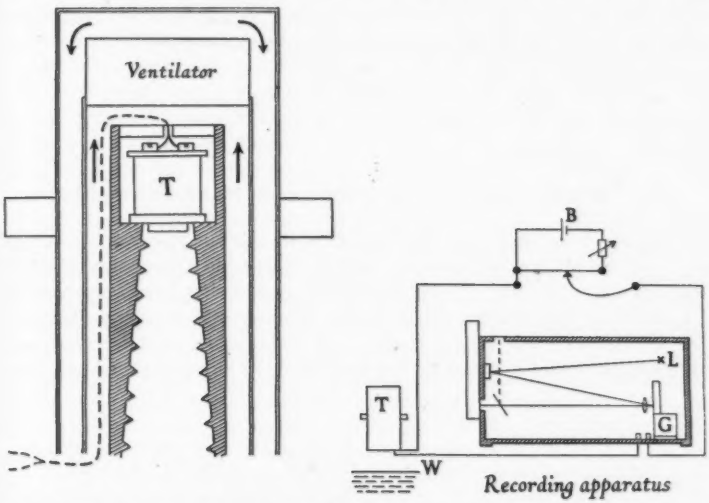


Fig. 2. Thermopile in housing and recording apparatus. T, thermopile; G, galvanometer; L, lamp; B, compensating bridge; W, surface of water

temperature of the radiating water surface. The voltage which is produced by the large mean temperature difference is therefore compensated, and only the changes are measured by the galvanometer (see Fig. 2).

The measurement is done by photographically recording the movements of the light spot of the galvanometer. The calibration of the recorded curve is done by using the radiation from the surface of rapidly running water taken alternately from two sources of known but different temperature.

To observe the surface temperature of water exposed to the free air in order to measure the supercooling effect it is best to avoid the sun-radiation and perform the measurements before sunrise. Having established one of my observation stations in a mountain region near Rondane (at Soernesset) shortly after Easter 1942, I have never in my life enjoyed so many brilliant sunrises terminating the preceding hours of work.

In one series of experiments I used an open basin with inlet and outlet

for the water, the temperature of which was slightly above 0° C. I allowed a sheet of ice to be formed and then suddenly increased the flow of water, causing the ice to be covered by a thin layer of water, starting with a temperature slightly above zero. I placed the thermopile above the basin at a distance of about 10 cm. with the opening downwards. The typical result of such measurements is given in Fig. 3.

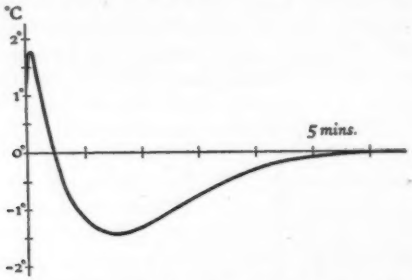


Fig. 3. Surface temperature of freezing water recorded by thermopile

When the decreasing temperature of the water surface passes 0° C., nothing happens, but the temperature falls farther and within a comparatively short time, between one or two minutes in this case, a temperature of approximately −1·5° C. is reached. Then the formation of ice crystals starts, needles grow over the surface from starting points, and in the course of the next minutes a network is formed growing denser and denser. The temperature registered

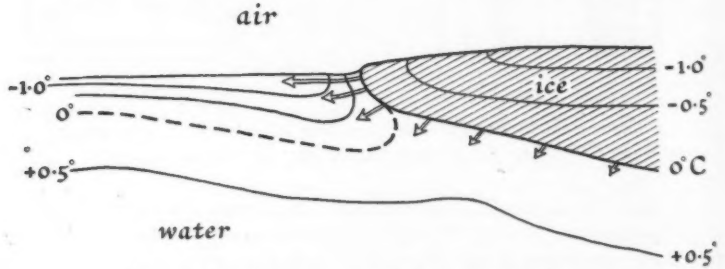


Fig. 4. Growth of an ice-crystal in supercooled water

by the thermopile rises correspondingly. This is because the temperature of the open spaces are still considerably below zero while the temperature of the thin needles will be practically zero. In fact if we drop some ice powder in the open spaces between the needles these will immediately be covered by a leaf of ice, indicating that the water had been considerably supercooled. When, in this case, five minutes had passed a coherent sheet of ice had been formed.

Fig. 4 shows how the growth of ice takes place when an ice crystal is starting to grow. The dimensions are exaggerated and the conditions simplified. The

arrows indicate the growth, which will of course be greatest towards those places where the temperature gradient is steepest. From the temperature distribution in the neighbourhood of the ice crystal surface the growth will evidently be greatest just in the surface layer. That is the reason why ice needles can shoot over the surface in an amazingly short time.

It is of fundamental importance to the understanding of the ice formation processes to bear in mind that this growth of ice into surrounding supercooled water is a process which takes time. Generally, this fact is not sufficiently realized and I believe that one of the reasons is due to the ordinary presentation of the supercooling effect, for instance, by cooling a solution of thiosulphate and then adding a few small crystals to start the solidification. In this case the crystallization takes place rapidly, but this is due to a very large amount of supercooling and to the comparatively small heat of solidification which is freed by the crystal process. In the case of supercooled water exposed to cooling in open air, the drop of temperature below zero will be small especially when the water is being mixed; and the heat of solidification is very considerable. In this case the process of solidification may take a very long time and we may expect the surprising result, in a lake or a river, of ice particles swimming or floating in supercooled water masses.

I have already mentioned that it is comparatively easy to measure supercooling in cold weather in open rivers which are cooled down to about 0° C. The first measurements of supercooling in rivers and lakes were made by Russian observers among whom I might mention particularly W. Altberg. In the running and turbulent water of the Neva he made observations during the years 1916–17 and 1920–21. He measured supercoolings which generally amounted to some hundredths of a degree C. but in peculiar cases, even −0·1° C. This supercooling was not only measured at the surface itself, but also in the intermediate layers and even at the bottom. He observed the formation of small ice crystals within the water and on the surface of objects under water. The formation of these ice particles did not do away with the supercooling which continued to exist irrespective of the ice crystals and the continuous formation of new portions. This process we shall consider in more detail in the next paragraph.

Ice formation in running water

The figures we have given on p. 195 concerning the loss of heat from a water surface exposed to open air show that under heavy frost the formation of ice would be very rapid as long as this loss of heat continued. In still water however the formation of a coherent ice sheet, a plate which increases in thickness, will more and more effectively reduce the loss of heat. From this point of view the process of ice formation may be considered as a counteraction aiming at reducing the heat loss and establishing a state of stability. This evidently requires a lowering of the temperature of the surface exposed to air approximately to that of the air itself. This is most easily attained when the ice is covered by snow which acts as a most effective insulating layer. (Compare Fig. 1.)

In the case of turbulent running water however the conditions are entirely different from those of still water. The water surface will be renewed every

moment and will be exposed to the maximum loss of heat, often for very long periods. When the river has been cooled down through the entire mass to about o° C., the loss of heat from the surface will produce supercooling. The supercooled sheet of water will however not be resting at the surface, but will be twisted and move in an irregular way through the section of the river. It will enter the turbulent motion and may just as often sweep along the bottom as be moving at the surface.

The result of this intermixing will be a changing structure of water masses at different temperatures slightly under o° C. Wherever such supercooled water currents contain solid particles or pass solid objects, ice will be formed. It is evident that the formation of ice on fixed objects will take place at the highest rate where the motion of the supercooled water passing by is greatest, because there the actual gradient of temperature will have extreme values. The consequence is that every peak of a fixed ice structure will have a tendency to grow, so that the irregularities will not be smoothed out, but on the contrary, exaggerated. The ice which is thus deposited under water is very loose and spongy. The supercooled water will however filter through and gradually fill up parts of the space between the walls and needles of ice. If we put a pole in the water for some hours we shall find it covered by a spongy ice structure. Ice which is growing on floating objects will be subjected to similar conditions, but not so extreme. In this way the running water will contain floating aggregates of growing ice sponges generally called frazil ice.

If the supercooling is sufficient and the turbulent action strong, there will also be formation of similar ice structures at the bottom of the river. In Norway and in northern countries generally the beginning of winter frost will very often be followed by the formation of this type of ice in the rivers. Under a hard frost the production may be very heavy and sometimes the river section may be partly filled with bottom ice, causing flooding of the river banks.

I have just emphasized the connection between the growth of the crystals and the movement of the supercooled water, and I mentioned the tendency which would exist for aggravating all peaks and sharp needles. This in its turn again will act as a brake upon the movement of the water and, keeping this in mind, we have the key to the understanding of the formation of the ice dams in running rivers. We may then observe the river running over an ice bed which has the appearance of a staircase. The front of each step is formed by an ice dam producing a water basin with a still surface. The ice dam has been built by the formation of bottom ice (anchor ice), the growth being most active where the velocity of the water is greatest. If the cold is persistent the dam may be built up in a comparatively short time.

By this means the turbulent river will be transformed into a series of dams, each with a comparatively still water surface which is very rapidly covered by a growing ice sheet. Provided that this process is not interrupted the loss of heat is slowed down and the formation of bottom ice will stop as soon as the water is covered by ice. Now two processes representing heat gain will more and more change the process. First, the radiation from sun and sky will balance part of the heat loss from the ice surface; and secondly, the water

running underneath will be slightly heated due to the energy produced by its falling down the slope. Instead of supercooling we may even find a slight heating of the water raising the temperature above 0° C. and accordingly some ice will melt. This will take place where the water is running fastest and consequently the stream will cut its way through the ice bed and after some time run in a channel the bottom of which is the river bed. It will have ice walls on both sides and if the width is not too great the ceiling will be formed by the ice cover of the previous basins, forming a sort of staircase.

This process is a remarkable example of how nature counteracts a disturbing process and re-establishes a new state of stability. If you are walking in the mountains, and I am sure you may observe it in England or Scotland during a hard winter, you will find brooklets and small rivers running chuckling underneath a thick cover of ice which will consist partly of a solid ice cover and partly of an ice structure which may sometimes remind you of a heap of rubble seen after an air raid.

In some rivers in both Norway and Sweden as well as in Russia and Siberia, the process which I have just described may be interrupted by a sudden change of temperature. If this takes place during the formation of ice dams, it may result in a breach of the dam. The water stored behind the dam will rapidly be released, the next dam will in turn be emptied, and if the slope is sufficiently steep a flood wave will rush down the river sweeping with it the ice masses and even causing great damage. Where the river takes a more quiet course the ice masses will be stopped and may be pressed into barriers of considerable height. In more southern latitudes ice formations in rivers may lead to ice floods of a similar character, if not on such a scale. Where such a wave of water and ice, carrying masses of ice blocks, forces its way, overflowing the banks, you will see the eroding power in action, a nature's bulldozer on a gigantic scale, wherever an obstacle tends to stop the advance.

Some practical applications

The formation of frazil ice, anchor ice, and ice dams may very severely hamper both traffic on the rivers and the efficiency of water-power installations. The chief places of production of frazil ice and anchor ice will be the rapids. Here anchor ice will be formed, especially below the rapids, and the frazil ice will be carried downstream and deposited in huge masses underneath those parts which have been covered by a continuous ice cover. Compare Fig. 19, p. 114, in 'Ice formation,' by H. T. Barnes (Chapman and Hall, 1906).

The precautions which may be taken to keep traffic going will evidently have to follow the example of nature itself: to reshape the river by reducing the rapids, eventually concentrating them by damming the water at proper places, thus producing the staircase which I mentioned above. If traffic is to go on, evidently locks will have to be established if necessary.

Hydraulic power-plants in northern countries may often be exposed to difficulties caused by the formation of frazil ice and anchor ice. In many of the Scandinavian plants, this has led to the application of artificial heating of the grids which are placed before the inlet to the turbines. There is, of course, no attempt to bring the temperature of the supercooled water as a

whole up to or above the freezing point. It will be sufficient to keep the surface of the grid slightly warmer than the water. It may however happen that this precaution will not be sufficient, and then it will be necessary to avert as much as possible the formation of frazil ice and bottom ice. From the analysis which we have given above of the nature of ice formation in running water, some basic principles governing the planning of precautions will clearly emerge.

First, the profile of any open channel leading water to the power plant must be sufficiently wide to reduce the turbulence of the water. Secondly, it might be advisable to accelerate the formation of an ice cover by placing wooden beams across the channel from which an ice layer could start growing upstream; this precaution is used in many cases. Thirdly, if the supercooling of the water cannot be fully avoided, it is of great importance to provide for a slow and smooth running of the water through the inlet channels to the tur-

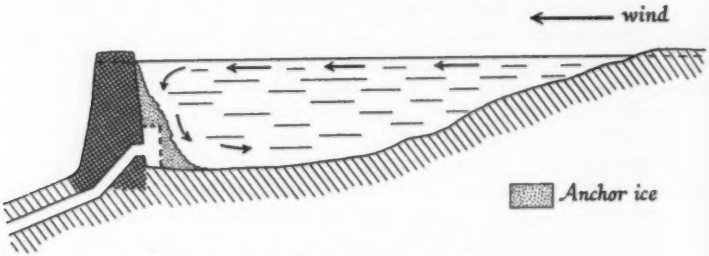


Fig. 5. Water main from reservoir choked by anchor ice

bines. Good results have been obtained by widening the inlet openings and shaping the walls and turnings as much as possible in a streamlined fashion.

In Norway I have also seen a few examples of bottom ice blocking the water supply delivered from a dam. Fig. 5 is a sketch of the reservoir supplying one part of Bergen in Norway. Some ten years ago when on a winter day a strong continental wind was blowing down the mountains and sweeping over the dam, the flow through the water main suddenly stopped. Nothing unusual could be seen on the dam, which was full of water with no ice on it. A diver went down to the inlet of the water pipe and found it completely covered by a thick crust of bottom ice. This was at a depth of 30 feet below the surface of the water. The production of this ice crust is easily understood: the water in the basin had been cooled throughout to about freezing point, the cold wind had partly produced supercooling and simultaneously started circulation in the reservoir causing supercooled water to go down the back of the dam and return along the bottom. The grid shielding the inlet of the tube presented the suitable starting surface for ice growth with the result just described. In the climate of Bergen it is most improbable that such a thing should happen often, and accordingly the only precaution which was recommended was the placing of a floating chain of wooden beams to counteract the circulation and start the production of a shielding ice cover.

The researches mentioned on p. 196 have been fully described in a paper printed in the *Geofysiske Publikasjoner* in 1942, but I was not able to bring a copy with me. The study of the temperature of the surface layer directly in contact with the air is of interest not only in connection with problems of ice formation. It will enter into a detailed study of the exchange of heat between water and atmosphere, and the results of our measurements indicate that considerable corrections will have to be made in the measurements of water temperature with thermometers if we want to know the real temperature of the separating boundary layer.

DISCUSSION

Before the paper the PRESIDENT (The Rt. Hon. Sir GEORGE CLERK) said: The reader of the paper this afternoon, Dr. Olaf Devik, is a Norwegian physicist, well known for his studies in Trömso, in Bergen, and in Oslo. Some fourteen years ago the Academy of Sciences at Oslo published an important memoir, which deals with the mathematical theory of his subject this afternoon: "The formation of ice in lakes and rivers." Dr. Devik's more recent experimental work is founded upon that theory and some of the more delicate experiments have been made, I believe, in the last few years. It is a subject which is of interest equally to the geographer and the hydraulic engineer, and both will be glad that circumstances have allowed Dr. Devik to describe the work this afternoon for publication in the *Geographical Journal*.

Dr. Devik then read the paper printed above.

The PRESIDENT: I gather there is no one present who wishes to add a word on this most difficult but interesting topic. I am sure we are all very grateful to Dr. Devik for giving us a paper on such an intricate subject, and one of which so few know anything. He has touched upon a question that will no doubt be developed and will lead, in due course, to great progress.

SOUTH-EAST VICTORIA ISLAND AND THE QUEEN MAUD GULF

CAPTAIN THE REV. H. R. ROKEBY-THOMAS
(Canadian Chaplain Service)

Meeting of the Society, 10 January 1944

THE natural approaches to the Canadian Arctic by sea being from the east and the west, has resulted in the Central Canadian Arctic being the last part of the area to be explored and opened up. Even to-day less is known about north-east Victoria Island than of the more northern areas north-east and north-west.

The Queen Maud Gulf is fairly well mapped in outline but is vague in detail, particularly in the south-east. McLoughlin Bay for instance seems to be much deeper than is shown on the 1933 35-miles-to-the-inch map of the Northwest Territories. I visited it in 1938 by sledge, in company with Douglas Cain, of the Royal Canadian Mounted Police, and that was our

impression, although very bad weather on the trip prevented us from getting any very accurate idea. The map made from photographs taken by Major Burwash and Walter Gilbert on their flight to the Magnetic Pole was useful, but some sections were not covered, and in the vicinity of Adelaide Peninsula it does not seem to be correct, some places marked as islands are really large shoals just under water.

Navigation in the Queen Maud Gulf is always treacherous because of the many shoals and islands. The Gulf is never entirely free of ice, some very old, which has come down through Victoria Strait, and it will never be feasible to take either large or small ships through at regular intervals. On several occasions the small schooner carrying supplies for the Hudson's Bay Post at Gjöa Haven, King William Island, failed to get far east of Cambridge Bay.

The Queen Maud Gulf is a very different proposition, either for ship or for sledge travel, from, for instance, Coronation Gulf. The navigation season is much shorter, seven weeks being a long season, and the period when there is good going in a favourable year would be around five weeks. High winds, especially from the north-east and the north-west, may force large areas of ice down Victoria Strait. Shoal water extends for a considerable distance offshore almost everywhere round the Gulf. Low reefs are numerous, and there has not as yet been any thorough Hydrographic survey. Mist and fog are prevalent. In the spring and summer mirage is not unusual, and can be very disconcerting to the traveller who does not know the area well and is depending on landfalls for obtaining bearings.

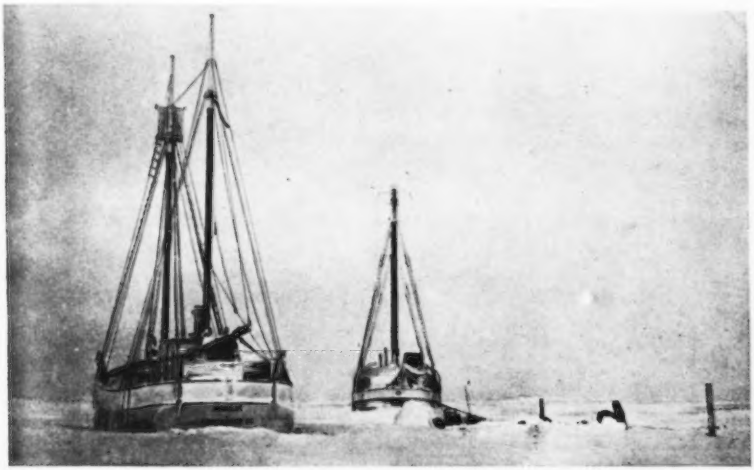
With the spring, tide-cracks occur at frequent intervals and often detours of many miles have to be made to find a crossing. In the fall pressure ridges of considerable size begin to form. In a smooth freeze-up these are a considerable help to travellers as they encourage drifting snow to pack, so that it is available for igloo building. Although the winter is long the snowfall is not large, and in some years it is a problem for the traveller on sea-ice in the fall to find enough drift snow to build an igloo. This has to be taken into consideration in planning a season's travel and in selection of routes. To have to go inshore to find snow may add both mileage and time to a journey, while the extra weight and discomfort of a tent is rarely a happy solution.

The condition of new ice depends on the kind of freeze-up in the fall; with old ice a calm freeze-up does not mean smooth sledging. The worst going is perhaps over small hummocks of old ice, not over large bergs. The hummocks, if smoothed by a partial thaw, are rounded, so that a sledge tends to slide in all directions at once, and frequently upsets on a sideways slide. It makes hard pulling for the dogs against a side as well as a frontal drag.

There is no consistent pattern or position for the rough-ice areas in the Gulf, whether old or new. However as a general rule the area around the islands at the southern end of Victoria Strait may be expected to be rougher than most other parts of the Gulf.

For sledge travel between Cambridge Bay and King William Island, both the white inhabitants and the Eskimos consider that the easiest journey is made by going south to Perry river on the mainland, making a land portage at White Bear Point, then heading east or north-east from Perry river according to the year. From Cambridge Bay to White Bear Point there is the alter-

C.A.L. plane photographed from the "St. Roch," offshore from Coppermine, August 1936



Phot. L. F. Willan

The "St. Roch" and the "Nigalik" wintering at Cambridge Bay

Phot. Thomas Wood

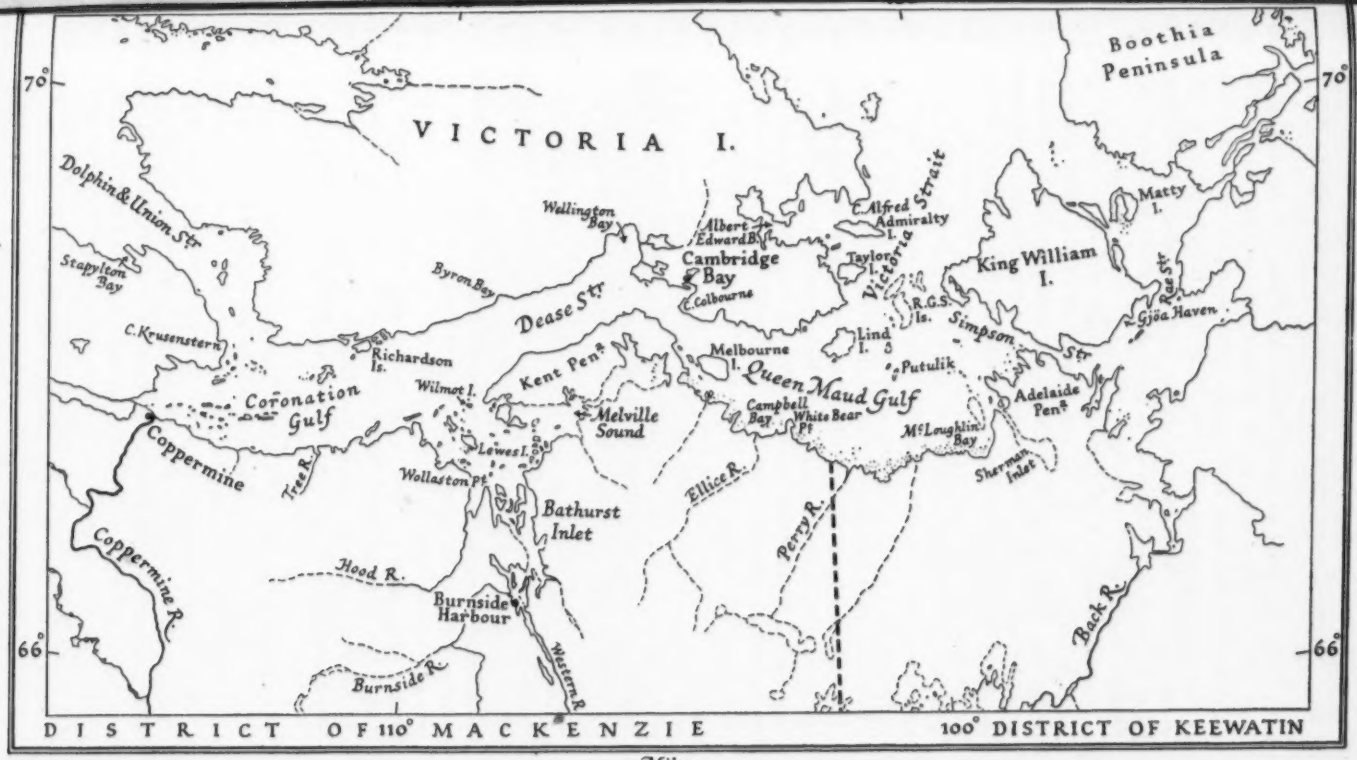
Air photograph of Bathurst Inlet

Phot. Thomas Wood

Looking south up Bathurst Inlet on flight from Coppermine to Cambridge Bay

Phot. Thomas Wood

Cambridge Bay looking S.S.W. from the RCMP Barracks. In centre Hudson's Bay Company Post, on right former Canalaska Post


VICTORIA I.
Boothia Peninsula
70°
66°
Dolphin & Union Str.
Stapylton Bay
C. Krusenstern
Coronation Gulf
Coppermine
Tree R.
Coppermine R.
Hood R.
Burnside R.
Burnside Harbour
Wellington Bay
Byron Bay
Dease Str.
Richardson Is.
Wilmot I.
Kent Pen.
Melville Sound
Lewes I.
Wollaston Pt.
Bathurst Inlet
Western R.
Albert Edward B.
Cambridge Bay
Colbourne
C. Alfred Admiralty I.
Victoria Strait
Taylor I.
R.G.S. Is.
Lind I.
Melbourne I.
Queen Maud Gulf
Campbell Bay
White Bear Pt.
Ellice R.
Perry R.
Back R.
Putulik
McLaughlin Bay
Sherman Inlet
Adelaide Pen.
Simpson Str.
King William I.
Matty I.
Gjöa Haven
DISTRICT OF MACKENZIE
110°
100° DISTRICT OF KEEWATIN
Miles
50 0 50 100

native of going inside or outside Melbourne Island. If the outside route is reasonably smooth it is by far the shortest and the best; but it can be very difficult in a bad season, while on the inside route the worst one expects to encounter is minor rough ice. From Perry river, if the rough ice is well down to the south, a course east inside the numerous off-shore islands gives a lot of protection and can be continued into Sherman Inlet overland to the east side of Adelaide Peninsula.

No one could go to the Queen Maud Gulf and not be interested in the Franklin search. The late William Gibson, who spent many years at Cambridge Bay working for the Hudson's Bay Company, has written what is I think the best account of what is known and not known about that expedition (*Beaver*, June 1937). Ever since I travelled overland to Albert Edward Bay from Cambridge Bay in 1935, I have felt that Albert Edward Bay raises the question not of the probability, but only of the possibility that some of the members of the Franklin expedition looked westward from Victoria Strait and tried that way out, perishing when they found it only led to the mouth of a river. Eskimos with whom I have discussed this were quite clear that while one group does fish at the head of the bay, and in some years go sealing in the spring down towards the mouth, there have been years when the bay has not been visited by Eskimos and that there are many bays and inlets on the southern shore that they never visit. The group that does fish in the area are only about twenty-five or less. There is a strong current running into the bay and small driftwood has been found on the seashore, which in such a remote and treeless place is remarkable. Albert Edward Bay has certainly been visited several times, Lieutenant Hanson, who was with Amundsen on the *Gjoa*, went across it by sledge, and in recent years, I think, the Mounted Police have visited it; but most of the work has been done on ice in the winter.

At present there are some seven hundred Eskimo in the district round the Queen Maud Gulf. As far as I could estimate with such a scattered population it appeared that the numbers were decreasing. It is interesting to travel from the mouth of the Mackenzie to Gjöa Haven and see the difference in the Eskimos at the eastern and western ends of the Queen Maud Gulf. Civilization penetrating from the west, the Eskimo at the western end are much further advanced than those at the eastern end. The Church has played a leading part in trying to see that progress is of the right kind. I doubt if any one to-day has a more intimate knowledge of the problems involved or has travelled as widely in that part as the Lord Bishop of the Arctic.

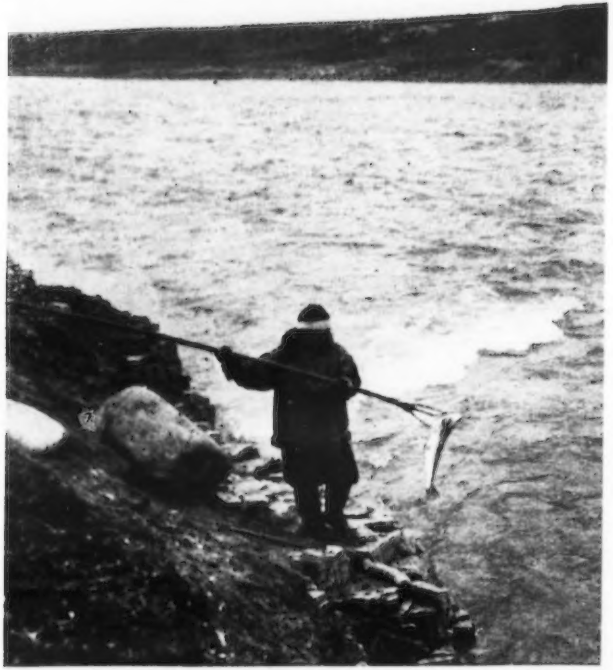
From before 1923 there has been continuous white habitation in the Queen Maud Gulf area. Cambridge Bay was the main centre with the Hudson's Bay Post, RCMP Barracks, and Anglican Mission, and for a time the Canalaska Trading Company had a post there. The Hudson's Bay Company are also established at Gjöa Haven and at Perry river, although the latter post was closed for several of the intervening years. The white population has varied from six or seven to over twenty, the larger number being during the years when the RCMP schooner *St. Roch* wintered at Cambridge Bay with a crew of between seven and eleven on board. At Cambridge Bay as many as five

Eskimos leaving Cambridge Bay for summer fishing and sealing camp at Albert Edward Bay. St George's Mission on right

Wellington Bay: Salmon split and hung up to dry

Phot. E. J. Gall

The "Aklavik" at Gjöa Haven, King William Island

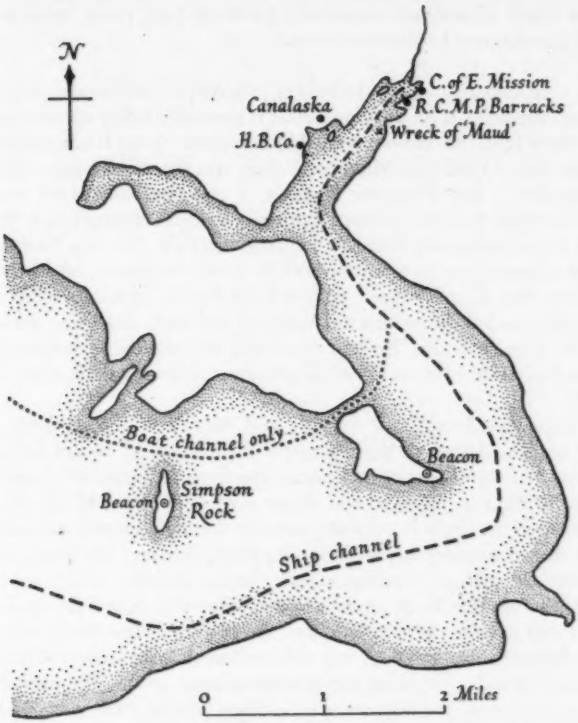


Eskimo spearing salmon in the Ekaluktuk river near its mouth in Wellington Bay

Eskimo child fishing through a hole in the ice

white women have lived there at various periods during the last decade, and two others have flown there on a visit. Three of the five were there at the same time in 1936 and 1937, and at least two white children have been born there. Generally white women have been very adaptable to Arctic life. My wife used to accompany me on sledge trips in the spring, and must have done several thousand miles in the three years she was at Cambridge Bay.

The houses at Cambridge Bay are built of wooden frames. Great care has to be taken to ensure that they are air-tight. Several layers of board are used,



Sketch of Cambridge Bay

each covered with tar-paper, and in the best houses they are ribbed with lathes between each layer to allow an air space of about a quarter of an inch. There is of course the usual space of 4 or 6 inches, the width of the joists, between the inside and outside walls. Houses built like this are quite comfortable to live in although usually rather small to reduce heating costs. Coal at Cambridge Bay was $200.00 per ton. Between 1934 and 1939 the lowest yearly consumption at the Mission House was 7 tons, and the highest 11 tons. To conserve heat the houses are usually protected by a 3 or 4-foot wall of

snow in winter, and the windows on the storm side covered with clear slabs of ice to supplement the three thicknesses of glass in the window. With these precautions the houses are usually reasonably warm. Quebec Heaters are used with both hard and soft coal, anything in the way of an open fire would be inadequate on a fuel : heat basis.

All food stores have to be imported. Vegetables and fruit are canned or dried except for cases of oranges, potatoes, and onions. Canned meat and bacon are also imported, though in a favourable year caribou are plentiful, and there is Arctic salmon in season, ptarmigan, and in summer wild goose. Various kinds of seal are reasonably plentiful, and polar bears are found around the entrance to Victoria Strait.

I am very anxious to give a picture of progress in the islands. To-day, with radio and airplanes, the Canadian Arctic is gradually being opened up. It was mainly from 1930 that radio was used in the Arctic by the Hudson's Bay Company, the Royal Canadian Mounted Police, and the missionary. Now almost every Hudson's Bay Company Post has a two-way short-wave set. In the Central Canadian Arctic perhaps the most valuable contribution to the increased use of radio was made by Donald Sturrock. In 1934 Sturrock came north at nineteen, as an apprentice clerk in the fur trade; after a winter at Cambridge Bay he spent three years at Gjöa Haven on King William Island. During that period, often short of supplies and fuel, and living most of one winter in a snow-house, he still contrived to maintain communications, demonstrating that even in the most adverse conditions short-wave could be reliable.

The Canadian Arctic is a desolate and remote land, but there is great mineral wealth. Although there are still no regular air routes north of the Arctic coast of the Canadian mainland, the pioneer flights of Canadian Airways, the Mackenzie Airways, and others have demonstrated that there is no real obstacle if the flight is necessary, except the high operational costs which can be reduced considerably with development of bases. My future wife flew to Coppermine in 1936, arriving in time for the wedding ceremony, while I, who travelled on the *St. Roch* from Cambridge Bay, was held up for seven days and was late for the wedding, and the Bishop of the Arctic, who was to have performed the ceremony, was also icebound more than 500 miles away at Herschel Island. Airplanes can operate almost all the year round, either on skis or pontoons, and also on wheels when landing-fields are developed.

While shipping will play some part in the development of the Canadian Arctic, owing to the congestion of the islands and shoal waters, there are not the same opportunities for Arctic routes as in the Russian Arctic. There is no reason why in some parts roads should not be easy to maintain and keep open, remembering that the snowfall north of the Circle is comparatively light and if conditions of drift are studied, a road could be kept fairly free by building it in such a way that drifts do not form.

There is much variety of scenery in the Arctic: mountains sheering down to the sea, vast plains and tundra, caves and rocks that compare with the rugged coast of Cornwall, and beaches of sand and shingle.

I cannot visualize the Arctic coast ever being the playground of the

majority, but if transport facilities are available at reasonable cost, many people who like cool summers may go to that region as tourists.

Meteorological results

From 1934 to 1939 I was official observer for the Canadian Meteorological Service at Cambridge Bay. Unfortunately all my observations, except for the minimum temperatures, were left in Canada.

Minimum temperatures (degrees Fahr.) at Cambridge Bay, 1934–35 (69° 01′ N., 105° 15′ W., 5 feet above sea-level)

	Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*
1	8	−16	−25	−57	−22	−42	−34	−24	13	37	49	34
2	5	− 6	−25	−61	−43	−43	−35	−18	14	50	52	36
3	4	4	−32	−63	−41	−40	−36	−11	15	38	54	36
4	19	10	−35	−60	−37	−30	−26	−15	14	38	57	38
5	20	4	−25	−53	−22	−32	−11	−20	31	39	48	34
6	12	− 2	−26	−39	−17	−38	−15	−17	22	43	45	30
7	20	− 1	− 7	−39	−32	−33	−26	2	29	41	53	30
8	21	− 6	− 1	−34	−30	−40	−16	0	28	43	55	35
9	15	−13	− 3	−48	−35	−32	−18	10	31	42	48	31
10	22	−14	− 8	−45	−29	−35	−18	3	31	42	44	31
11	25	− 9	− 5	−47	−15	−38	−26	− 3	31	43	41	30
12	20	− 4	−13	−49	−32	−40	−31	−14	33	36	37	28
13	− 2	−14	−25	−51	−39	−35	−26	−31	32	38	36	33
14	− 1	−35	−28	−38	−43	−37	−31	−30	32	37	43	35
15	− 6	−21	−29	−41	−32	−38	−29	−12	36	41	43	31
16	−11	−21	−38	−42	−39	−45	−34	1	36	43	38	28
17	−11	−19	−38	−42	−40	−48	−34	6	33	44	40	29
18	− 4	−19	−34	−48	−40	−36	−30	28	35	43	38	29
19	− 4	− 8	−40	−47	−39	−35	− 1	25	34	40	41	27
20	− 2	−21	−40	−49	−35	−40	4	25	34	41	39	25
21	− 9	−20	−44	−44	−39	−45	−12	25	33	41	40	25
22	−14	−26	−36	−18	−40	−24	− 8	32	44	40	43	20
23	−12	−19	−39	−38	−41	−33	14	25	42	43	43	19
24	− 5	− 4	−44	−38	−40	−25	8	25	36	42	40	19
25	− 2	− 8	−46	−40	−27	−20	2	14	35	47	35	17
26	− 4	− 9	−53	−42	−21	−15	−13	16	37	48	35	15
27	− 5	−12	−55	−47	−35	−15	− 4	18	38	45	37	20
28	− 5	−16	−55	−47	−37	−14	−12	26	44	47	34	29
29	− 6	−27	−54	−20	—	−18	− 8	24	38	50	36	26
30	−11	−23	−54	− 6	—	−21	− 2	16	38	49	31	21
31	−14	—	−57	− 3	—	−32	—	13	—	48	36	—

DISCUSSION

Before the paper the PRESIDENT (The Rt. Hon. Sir GEORGE CLERK) said: In 1939 the Rev. H. R. Rokeby-Thomas contributed a short paper to the *Geographical Journal*, which greatly interested our principal authorities on polar travel. We are therefore particularly glad that he is in England with the Canadian Chaplain Service and is able to-night to give us some account of his journeys in Victoria Island and the Queen Maud Gulf.

Captain the Rev. H. R. Rokeby-Thomas then read the paper printed above, and a discussion followed.

The PRESIDENT: Towards the end of Captain Rokeby-Thomas's discourse I really began to think he had been living in an almost livable country, and I had to bring myself back to realities to appreciate that for five years he had lived in a region where a settlement of about twelve white people was accounted an

almost overcrowded city. I quite agree with what he has said about air travel. Mineral research may bring these desolate uninhabitable regions into the picture of the life of the world. I think we owe a great deal to men like our lecturer to-night who has spent five years in this region. You have seen for yourselves the surroundings in which he spent those five years, and you can imagine what the time must have been like. He has succeeded in bringing before us, if not the charm, at all events some of the glamour and a great deal of the interest of this arid and frozen space. He has also given us some idea of what the spirit of man can do when he sets out to accomplish the work which lies in front of him. Although as a geographical Society we owe thanks to our lecturer to-night, I think we owe still more to him for showing us what man can do in surroundings such as these.

Lieut.-Commander Q. RILEY, R.N.V.R.: Eighteen months ago I got married, and before I did so I said to my prospective wife: "When the war is over and we get down to some work I reserve the right to go into the Arctic or the Antarctic for a period of not exceeding five years." I am quite convinced that if one tries to spend less time than that one cannot learn very much about the country. It was my happy privilege to spend a year in Greenland in 1930, and another year in 1932–33, and also 1934–37 in the Antarctic, but I very much regretted that I did not spend four or five years in Greenland to start with and four or five years in the Antarctic. Captain Rokeby-Thomas has been talking about a part of the world which after the war I hope to go to, probably not as an explorer, for I shall then be too old, but perhaps as one of the tourists of whom he has spoken. His lecture has therefore been of particular interest to me and I am glad to have this opportunity of thanking him for a most delightful evening.

Dr. BRIAN ROBERTS: Those who are interested in the Arctic and who read Captain Rokeby-Thomas's very brief paper in the *Journal* of May 1939 have been looking forward to this meeting, and they will not have been disappointed. Perhaps he can enlighten us on one point. I understand that east of Perry river every one uses fan formation when driving their dogs, and that in the whole of the area farther west they use the Nome hitch. It also seems that travellers going from east to west become converted to Nome hitch. Is there any clear line of delimitation between the two methods? Do travellers who have learnt their technique in the Western Arctic also change their methods when they settle in the Eastern Arctic? I have been wondering whether these different usages are a matter of tradition copied from the local Eskimos; whether differences in the type of country can be considered in any way responsible; or whether there is universal agreement amongst those who have tried both methods that the Nome hitch is best for all conditions in the Canadian Arctic?

Captain the Rev. ROKEBY-THOMAS: There does not appear to be much to choose between the two methods. One follows local custom, thus there is no definite line of delimitation between the two styles. Fan formation is suitable for rough country, and Nome hitches can be varied so that they are also suitable for rough country, a longer line and greater freedom being given to each dog where the going is difficult.

The PRESIDENT: I am sure Captain Rokeby-Thomas is very glad to have enlisted one five years' tourist in Commander Riley. If there are no more comments it only remains for me to express the grateful thanks of those present to the author of the paper.

MITTELDEUTSCHLAND: THE MIDDLE ELBE BASIN AS A GEOGRAPHICAL UNIT

R. E. DICKINSON

CENTRAL GERMANY, or *Mitteldeutschland*, is a term which is applied by German scholars to the whole or part of the middle Elbe basin in Germany south of Magdeburg. The demands of long-range land planning in respect of the extensive lignite quarries and the industry and settlement associated with them, as well as the need for creating more rational administrative units, have prompted numerous studies in the last twenty years, many of them under semi-official auspices, of the economic character of this area and the interrelations of its parts.[1] In this article it is intended to examine in what sense and in what measure the middle Elbe basin may be considered a geographical unit.

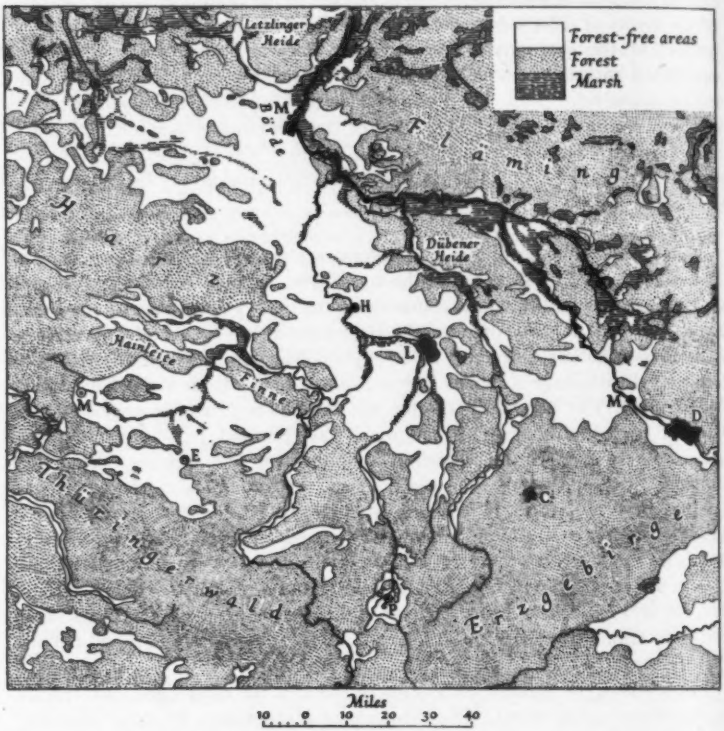
The middle Elbe basin above Magdeburg is framed by the Erzgebirge and Thüringerwald–Frankenwald to the south; the isolated block of the Harz to the north-west; and the most southerly of the great glacial troughs (*Urstromtäler*), the wide marshy plain of the Schwarze Elster–Elbe and its westward continuation in the Ohre and Aller beyond Magdeburg, to the north. The whole of the drainage is carried by the Saale and the Mulde to the Elbe, above Magdeburg. The highlands, sloping and drained northwards, enclose a lowland of varied physiographic features. This lowland falls into two parts, appropriately named the Thuringian and Saxon, or Leipzig, Bays. The drainage of the former is collected by the Unstrut and the Saale, and of the latter by several rivers, the western group from the Vogtland converging on Leipzig, the eastern group, draining the Erzgebirge west of the Elbe northwards by the Mulde to the Elbe at Dessau. The focus of this drainage system and of its natural routes lies in the plain around Halle, on the Saale, and Leipzig at the confluence of the Pleisse and Weisse Elster, the two cities being about 35 kilometres apart and the rivers interconnected by the broad marshy floor of the Elster.

In the history of human occupation of the area the most significant feature is the natural plant cover. The evidence of place-names, history, plant-life, and soils reveals a great area of forest-free land, with a steppe flora akin to that of the steppe lands of Eurasia, developed on the areas of smooth relief with a rich black loam soil of loess origin. This was the area of earliest rural settlement. To-day it is one of the most productive farming regions in Germany, open and treeless, with hedgeless fields of arable cultivation. It was completely encircled by forested uplands to west and south, and by heath and forest-covered glacial uplands with extensive areas of marsh and meadow

[1] 'Landesplanung im Engeren Mitteldeutschen Industriebezirk: Ihre Grundlagen, Aufgaben und Ergebnisse,' 1932, contains maps and proposals based upon elaborate investigations of conditions in the lignite-producing area around Merseburg. There are thirty-nine maps, some of which cover a large part of eastern Germany (including Berlin) on a scale of 1 : 1,000,000, and more detailed maps, on a scale of 1 : 200,000, cover the smaller region of the survey.

to the north. During the *Rodungzeit*, about A.D. 500–1400, these forests were cleared over large areas, leaving only the areas of roughest topography and poorest soils under forest to-day.

Four areas can thus be distinguished: the forest-free loess areas of prehistoric settlement; the cleared forest areas of medieval settlement, mainly in the Saxon Uplands and the uplands of the Thuringian basin; the forested



Natural vegetation of Mitteldeutschland: Forest-free areas of early settlement; Forest areas, with extensive clearings in medieval and later times; and Marsh areas.

areas of to-day; and the uplands to the north with forest and heath with large areas of cleared land, and great stretches of swampy moorland especially on the floor of the Elbe and Schwarze Elster.

The forest-free loess area is a part of the great belt which extends across Europe on the northern edge of the Central Uplands (Mittelgebirge), but here it broadens out to form the greatest single clearly defined area of its kind in Central Europe. This area has its nucleus in the Leipzig Bay, from which there are three extensions: south-east to Meissen and Dresden and Pirna on

the Elbe; north-west in a belt 50 kilometres wide between the Harz and the Elbe (Magdeburg Börde), narrowing westwards and disappearing between the western end of the Harz and the hills to the north; and west in the basin of Thuringia, as far as the wooded hills with frequent clearings between the Harz and the Thüringerwald, which form a circle around the basin of the Unstrut. There are forest barriers, remaining to this day between these sectors of the primitive forest-free land. Most notable is the wide zone of forested uplands along the Unstrut and the Saale, which separate the Thuringian area from the rest, and the Dübener Heide and its continuation southwards on either side of the Mulde valley separating the Meissen–Dresden area. But these open forest-free and early settled areas are sufficiently close to have had persistent contact, and the whole area is well defined by the encircling forest in the highlands to the south and west, and the glacial uplands to the north. Together they form a definite unit in the sense that it is a clearly defined nucleus, in the history of human settlement, and is surrounded by great areas of wooded and less fertile country, which were affected by medieval settlement. These areas are, to this day, different in their landscapes and their economic character, and their contrasts are clearly reflected in the distribution of population.

The rich arable loess soils form an agricultural region which contrasts markedly with the neighbouring lands on all sides. This is well shown by the distribution of the proportion of arable land to the total land area of small districts.[1] A large area with over two-thirds of the total land area devoted to arable cultivation, lies between a line to the north from Braunschweig to Magdeburg and along the Elbe plain from Magdeburg almost to Dresden, and a line to the south due west from Dresden, as far as Mühlhausen. The proportion of arable land actually reaches 80 per cent. in the Harz Foreland and 70 per cent. in the Leipzig Bay. From this great nuclear area, corresponding to the main forest-free plains of loess, the proportion of arable land falls rapidly on all sides to 35–50 per cent. in the lowlands north of the Elster–Elbe–Ohre trough, and decreasing to only 20–35 per cent. in the uplands to the south and west.

Relief and the natural vegetation cover are clearly reflected in the direction of medieval routes, which persisted as the only routes until the advent of the railway, and considerably influenced the economic and political development of the area. The Saale was a political, cultural, and settlement divide between Germans and Slavs in the early Middle Ages. With the spread of German settlement eastwards during (and after) the twelfth century, the area became a great crossways of routes between the lower Rhinelands and eastern Europe, between Lübeck, and later Hamburg, and Frankfurt and Nürnberg. Especially important are the relatively low-lying, or open exits from the basin to the north-west, along the northern foreland of the Harz (the heart of medieval Saxony); across the wooded Eichsfeld plateau to the west, between the Harz and the northern end of the Thüringerwald; to Göttingen along the southern foot of the Harz (*Goldene Aue*) and to Eisenach (at the northern end of the

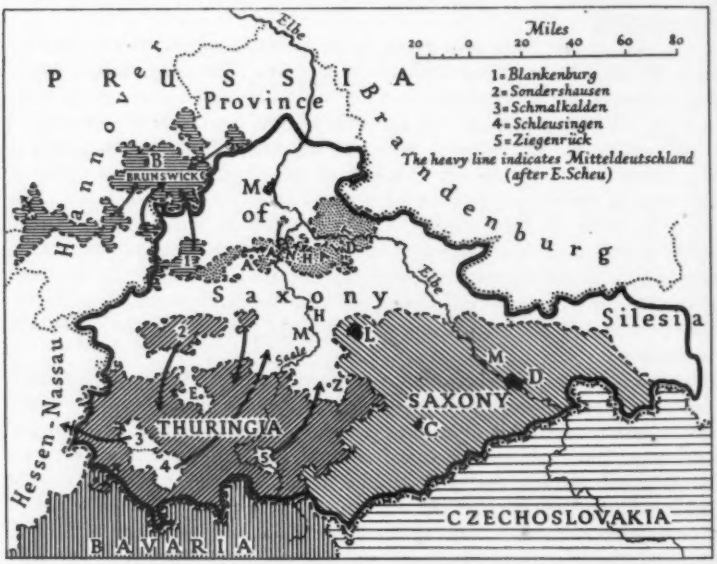
[1] See N. Krebs, 'Die Verteilung der Kulturen in Deutschland in Festschrift zur Hundertjahrfeier des Vereins für Geographie und Statistik zu Frankfurt am Main,' 1936. Also the 'Atlas des Deutschen Lebensraumes.'

Thüringerwald); east to Dresden, linking the towns of Upper Lusatia with Breslau; south up the Elbe gorge to Prague; and due south across the Vogtland between the Frankenwald and Erzgebirge, where forest-free land in the wooded uplands favoured the early growth of Plauen and Hof, and their development on the great route from Nürnberg to Leipzig.

These were the main natural exits, and therefore the earliest to be used as routeways. From all of them belts of open treeless country lead direct to Halle and Leipzig. In the Middle Ages these two cities became the focus of these and other roads which followed more difficult courses: one across the Thüringerwald (Jena–Coburg) and another across the Erzgebirge (Chemnitz–Prague), while several routes radiated north-eastwards across the Elbe. At the end of the Middle Ages there was no road direct to Magdeburg, which lay at the river-crossing of the great east–west overland route from Cologne.

Political groupings

In the early Middle Ages, Central Germany was a frontier province and fell into two distinct parts, separated by the Elbe and Saale rivers. Under the



Political divisions and extent of Mitteldeutschland (after E. Scheu)

Carolingian Emperors this was the eastern boundary of the Reich, and the divide between the spheres of German and Slav settlement. The vast Slav territories between the Saale and the Elbe above Magdeburg were conquered in the tenth century and divided into the marks of Merseburg, Zeitz, and Meissen. These became the nucleus of the Wettinian dynasty and their kingdom of Saxony, while Altmark to the north, with its centre in Aschersleben,

became the nucleus of the Hohenzollern territories of Brandenburg, out of which grew Prussia. The political fate of Central Germany stems from these two powers.

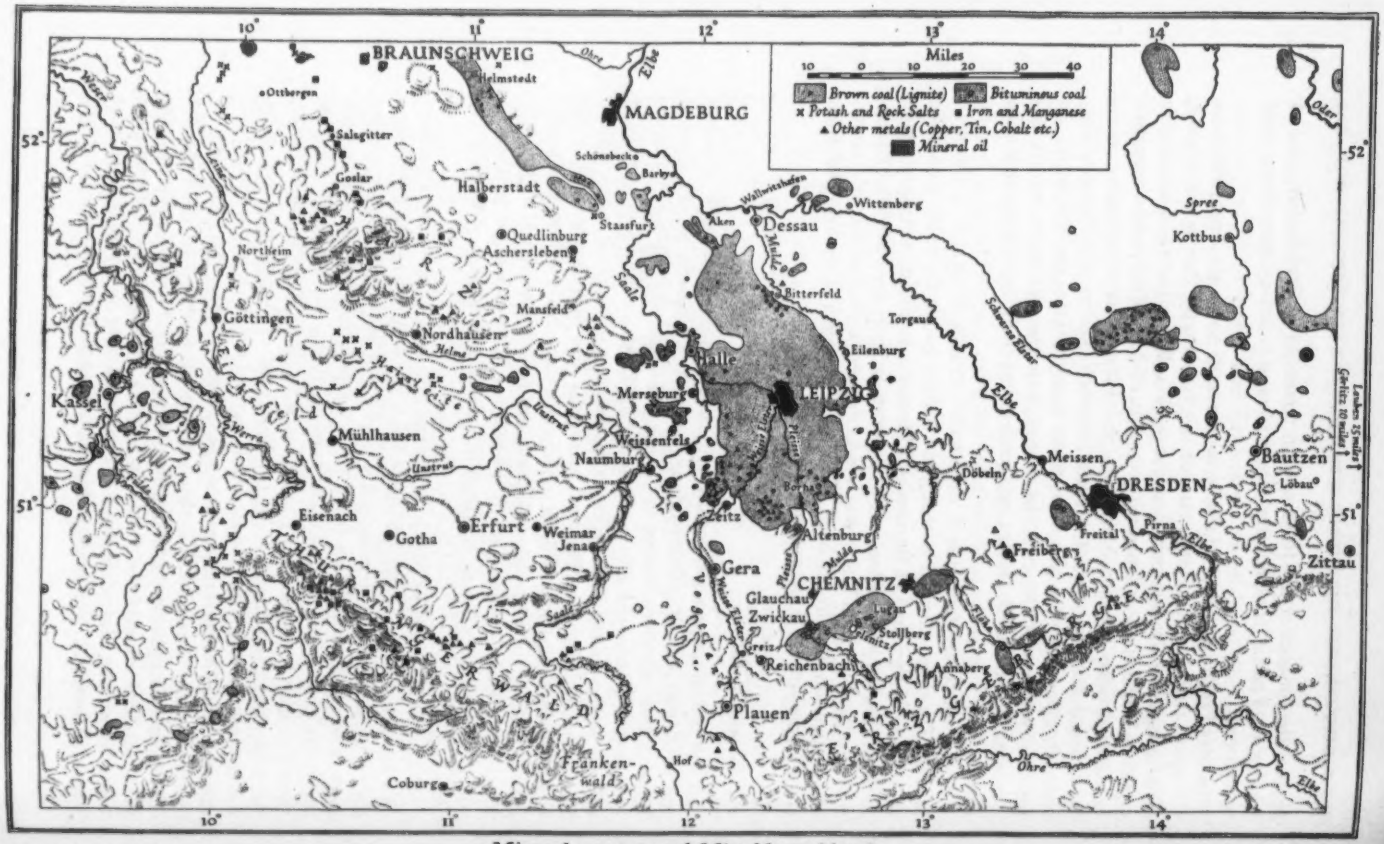
In 1815 Prussia absorbed all the Wettinian lands north of Leipzig and most of Upper Lusatia, which were organized, in 1818, into the Province of Saxony. This "geographical monstrosity," as Penck has called it, has its administrative capital in Magdeburg, its University centre in Halle, and other administrative functions divided between Merseburg and Erfurt. Anhalt remained as an independent political unit as a buffer between Saxony and Prussia. This State, though even more of a monstrosity than the Province of Saxony, has persisted with very little territorial change from the thirteenth century onwards, with its capital in Dessau, and has a strong tradition of unity among its inhabitants.

To-day there are four States, or *Länder*: Prussia (Province of Saxony), Saxony, Thuringia (formed in 1920), and Anhalt, and in the north-west there are outliers of the *Land* of Brunswick. There are in addition many outlying territories embedded in these States; for example there are outliers of Brunswick (Blankenburg) and Thuringia (Sondershausen) in the Province of Saxony. Much attention has already been given to the problem of the reorganization of the administrative limits in Central Germany.

Population distribution

A belt of high population density, with high concentrations of both urban and rural populations, extends along the northern border of the Central Uplands from northern France to Galicia. This includes the zone of fertile loess soils together with the coal and lignite fields; and the industrialized uplands to the south. The largest populous area in this belt is the middle Elbe basin in Germany. This is a triangular area with its corners in the Görlitz–Bautzen district of Silesia to the south-east, the Hof district of north-eastern Bavaria to the south-west, and the foreland of the Harz and the Magdeburg Börde, merging into the territory of Brunswick to the north-west, while the whole area has its centre in the neighbouring cities of Leipzig and Halle.

The southern boundary of this area is fixed by the German–Czech frontier. In spite of the fact that this frontier follows the summits of the Erzgebirge, the populous industrial areas on either side of it in Saxony and Bohemia form parts of one great population block. It is the political frontier that for centuries has determined the contrasts between them. To the north and east there is a sharp break in density in the marshy plains of the Schwarze Elster, the Elbe, and the Ohre and Aller valleys west of Magdeburg (the route followed by the Mittelland canal); while beyond are the thinly peopled rural expanses of heath and forest-covered uplands and marshy valley floors of the North German Lowland. To the west the populous area includes the Thüringerwald uplands, beyond which there are more thinly peopled areas in the wooded areas of the Fulda and Werra basins. In this direction the border is without clear definition; it is a broad zone between two series of towns, Halberstadt, Nordhausen, Mühlhausen, and Eisenach, which are tied



Mineral resources of Mitteldeutschland

up with the *Mitteldeutschland* region, as against Kassel, Goslar, and Braunschweig, which belong to the *Niedersachsen* region.

Five great cities, each with over 200,000 inhabitants, dominate the economic life and organization of the whole of this area, Leipzig (701,600), Dresden (625,170), Chemnitz (334,560), Magdeburg (334,360), and Halle (220,360). Smaller towns, with about 100,000 inhabitants or a little under, are Erfurt (166,660), Plauen (110,340), and Dessau (120,730), and, not far below this limit are Gera, Zwickau, and Görlitz. There are about thirty towns with between 20,000 and 50,000 inhabitants. The greatest population clusters are grouped around Chemnitz, Dresden, and Leipzig–Halle. Small towns, ancient centres equally spaced on the old trade routes, are characteristic of Thuringia and the Harz Foreland between Halle and Braunschweig. The biggest of these are Jena, Weimar, and Eisenach, each with just over 50,000 inhabitants. (Figures are for 1939.)

From these broad facts one may deduce, on the one hand, that this area is distinct from its neighbours in virtue of its high density of urban and rural population, its high degree of industrialization, its close network of routes, and its intensity of traffic; and, on the other hand, that within it there are markedly contrasted economic regions which for this reason are likely to be complementary.

Industrial structure

In the middle Elbe basin there are great contrasts in the economic structure of Saxony and Thuringia in the south, and the Prussian Province of Saxony and the State (*Land*) of Anhalt in the north. (See Tables 1 and 2.)

Table 1. *Persons occupied, plus dependents as percentage of the total population* (1925)

	Province [1]				*State* [2]
	Saxony	*Anhalt*	*Brunswick*	*Thuringia*	*Saxony*
Agriculture	23·5	18·5	19·8	20·9	9·1
Industry	42·2	47·7	43·1	50·0	56·4
Trade and Transport	16·0	14·0	17·0	12·8	16·7
Administration ..	4·4	4·6	5·0	4·7	4·8
Health Services ..	1·3	1·3	1·6	1·2	1·5
Domestic Services ..	3·0	3·0	2·6	2·0	2·2
No Occupation ..	9·6	10·9	10·9	8·4	9·3

At the end of the Middle Ages, say in 1500, the northern section covering the fertile forest-free loess lands, was an exclusively agricultural area. Two minerals were mined from early medieval times in the Harz Foreland, salt and copper. The southern section, Saxony–Thuringia, for the most part hilly, wooded, and infertile, was settled in the Middle Ages. Mining and smelting, beginning near Freiberg in 1165, reached their peak in the fifteenth and sixteenth centuries, when a number of new towns were founded, including

[1] Proportion in industry (and agriculture) in *Regierungsbezirk*: Magdeburg 36·3 (25·5), Merseburg 46·1 (22·5), Erfurt 45·7 (21·5).

[2] Proportion in industry (and agriculture) in *Kreishauptmannschaft*: Leipzig 51·1 (8·9), Dresden 50·4 (9·8), Zwickau 63·9 (6·9), Bautzen 54·8 (17·6).

Table 2. Persons in selected industries as percentage of all persons occupied in Industrie, Bergbau, Baugewerbe in 1925 [1]

	Province Saxony	*Anhalt*	*Brunswick*	*Thuringia*	*State Saxony*
Total occupied, industry and mining ..	624,000	72,500	99,500	412,900	1,600,500
Per cent. of Reich total	(5·0)	(0·58)	(0·80)	(3·32)	(12·82)
Metals and machinery	17·9%	30·3%	23·7%	20·6%	20·5%
Foods	14·4	15·4	18·2	8·2	8·3
Mining	13·2	7·0	8·1	3·8	4·1
Clothing	11·5	7·3	9·2	8·3	10·0
Textiles	3·3	—	3·8	13·5	26·5
Chemicals	7·3	8·4	1·8	—	1·5
Paper	4·2	3·7	3·7	4·0	7·0

Annaberg in the heart of the Erzgebirge. In the north this general picture did not appreciably change during the ensuing two centuries, but in the southern half there were important changes. The kings of Saxony were able to foster industry to an extent which was impossible in the scattered small territories of their cousins in Thuringia. With the decline of mining and smelting, the textiles industries, absorbing the surplus labour unable to feed itself in a poor land, were developed as cottage industries, and became of increasing importance throughout the countryside. In Thuringia similar domestic industries grew in the uplands together with woodworking, and the making of glass and porcelain; whereas the lowland remained agricultural with industry confined to the towns. In the nineteenth century the small coal-field of Zwickau gave a further stimulus to industry in Saxony, although, until the use of lignite as fuel, running water was the main source of power for workshop and factory. Alongside the textile industries grew the manufacture of machinery and chemicals. Thus Saxony, to-day the most densely populated major province of Germany, is much more industrialized than Thuringia, but the two have essentially the same character, in that they have highly skilled industries drawing their material from elsewhere, dominantly textiles and metal working, and some industries which still depend primarily upon the presence of local raw materials.

The latter half of the nineteenth century has witnessed an industrial revolution in the Province of Saxony, and the State of Anhalt. Industry in the past grew from the local agriculture and from local natural resources. Lignite, or brown coal, was used in a small way as a domestic fuel in the eighteenth century, but its large-scale exploitation in the nineteenth century followed upon the growth of the sugar beet industry in the 'thirties on the model farms of the area, and the industries which grew up in association with it. In 1860 58 per cent. of the brown coal was consumed in sugar factories, 26 per cent. served

[1] From Thormann and Staab, 'Der Mitteldeutsche Raum, seine Natürlichen, Geschichtlichen, und Wirtschaftlichen Grenzen,' Merseburg, 1929, p. 69. For Table I, see pp. 52–54.

domestic uses, and 16 per cent. was used for other industrial purposes. In the 'seventies, the manufacture of briquettes brought great changes, since it permitted the fuel to be distributed over a wider radius and it could be used for a much greater variety of industrial purposes.[1] The distillation of lignite in the 'fifties, and other later processes, such as low-temperature carbonization and hydrogenation, resulted in the production of a great variety of chemical by-products. One of the most remarkable developments in the use of lignite has been the generation of electricity for long distance transmission from vast power plants adjacent to the lignite quarries. The development of other large-scale chemical industries was further facilitated by the proximity of potash salts. The production of the latter did not begin until the 'fifties near Stassfurt, where they occur with rock salt. These salts are now the world's chief single source of supply. Since they contain only 20–40 per cent. of pure potash, they must be processed before they can be used as fertilizer; the large quantities of fuel required are obtained from the neighbouring lignite quarries. Great chemical industries using both salt and lignite, and located near the latter have grown since the 'nineties, with Bitterfeld as the chief centre. These industries made great strides during the war of 1914–18 for the manufacture of gases and explosives, using nitrogen extracted from the air. Vast works appeared at Bitterfeld and Leuna. The chemical industries have continued to grow in the inter-war period (1918–38): soda, paraffin, chlorine, nitrogen, tar, artificial silk, photographic products, etc. There are also numerous large brick-works near the lignite quarries. To-day, the chemical industries consume a third of the lignite production. The whole of the modern industrial economy of this area is based on its mineral resources: salt, potash, and, above all, lignite, in contrast to the industries of Thuringia and Saxony, which are based on labour supply.

Economic regions.—We may recognize four economic regions:

(1) West Saxony (west of Freiberg and Döbeln), and East Thuringia (including in the latter the *Kreise* of Gera and Greiz and the Prussian *Kreise* of Zeitz, Weissenfels, and Naumburg, the western border corresponding with the forest east of the river Saale, where there is a sharp break in the density of population, and west of which neither population nor industry is so concentrated), specialize in the metal and machine industries and are the chief producers of textile goods in Germany. The chief towns are Leipzig, Chemnitz, and Plauen, and Leipzig its capital. Its main axis of population and industry runs east-north-east–west-south-west through Chemnitz, Zwickau, Reichenbach, Greiz, Plauen, and Hof.

(2) The East Saxony and Upper Lusatia area is centred on Dresden. Neither textiles nor iron and steel industries are dominant here. This is an area of mixed industry. The principal industries are metal working; chemicals (photographic and pharmaceutical products); glass-making and paper-making on the Elbe. The eastern Erzgebirge is oriented both economically and geographically towards Dresden, whereas the Flöha valley (cotton manufactures) is more closely allied with Chemnitz. The linen, and more modern cotton, industries in Upper Lusatia are centred in Görlitz and Lauban, and in Zittau

[1] See G. von Geldern-Crispendorf, 'Die Deutschen Industriegebiete, ihr Werden und ihre Struktur,' 1933.

and Löbau in the extremity of Saxony. (The historic unity of the Lusatian area is reflected in the Six Cities *Bund* in the past.) The industry is fed by the Lower Lusatian lignite field. East of Görlitz, the economic character changes and both industry and population densities fall off. The unity of this area in Upper Lusatia, historically and economically, is undoubted. It is a moot point whether its associations are closer with Saxony or Silesia; the nearness of Dresden would indicate the former. To the north the boundary is formed by the frontier of Brandenburg along the belt of heath land. Dresden (625,170) is the centre of an urban industrial area which extends from Meissen to Pirna. It is surrounded within a few miles by several small towns with 10,000–50,000 inhabitants in which heavy industries are characteristic, whereas Dresden, the "garden-city" of Germany and the political capital of Saxony, is a centre of miscellaneous light industries, heavier industries being located on its south-eastern outskirts.

(3) Thuringia, between the Harz and Thüringerwald (and including the latter), has its capital in Erfurt, situated in the centre of the area, although it lies in an outlier of Prussian territory. Thuringia is mainly agricultural in the lowland with small scattered towns, very ancient in origin, and to-day specializing in light, skilled industries. Especially notable are the series of towns, strung at equal distances along old routes, like beads on a chain, through the Goldene Aue to the north, and the series running east–west through Erfurt itself. Jena is the centre of the Carl Zeiss works. Industry is more widespread, in town, village, and country workshop, in the Thüringerwald, and the density of population higher than in the lowland, though the soil is far less productive and the country is mainly forested. Metal working, machine, and tool-making, glass-making, toys, and porcelain are its chief industries.

(4) The southern part of the Province of Saxony, and the State of Anhalt, form a single economic unit between the Harz and the Fläming Heide, with its economic centres in Magdeburg and Halle. Its essential character is the combination of open, highly productive farm land (wheat, sugar beet), and large-scale industry with lignite quarries and potash salt mines, brick-works, sugar beet factories, chemical works (*e.g.* Leunawerk at Merseburg, the greatest in Germany), and electricity plants (*e.g.* Golpa-Zschorne-Witz). Halle is the geographical focus of this area, which includes the *Regierungsbezirk* of Merseburg and the *Land* of Anhalt, but its limits are not clearly defined, the area merging gradually into Brunswick and the Leipzig Bay, where the above are mixed with other industries. The political frontier separates this region from the State of Saxony. The northern sector, north of the Harz, includes ancient towns and old metal-working centres which, historically, have been closely associated with Niedersachsen to the west, but are economically turned towards the river port and rail centre of Magdeburg.

In this new industrial area heavy industrial plants are relatively few and very large, and are grouped around or near to the lignite quarries, in the midst of one of the richest agricultural areas of Germany. Nearly all the urban settlements are small, with under 50,000 inhabitants. Special problems arise in the valuable loess land through the recent exploitation of the lignite beds, which underlie it, and the growth of heavy industry, problems which involve

a compromise between the demands of farming and industry. Great areas of rich soil have been destroyed to make way for the lignite quarries, villages cleared, and provision made for the disused quarries to be put to profitable use again. There are problems of the disposal of industrial refuse, the provision of water and power to the plants, the distribution of electricity by overhead and underground transmission lines, the migration of farm workers to the factories, and the daily movement of workers and associated transport and housing problems. Hence the urgent need for the planned rather than fortuitous development of these areas.

Commercial structure

In spite of the deep-rooted contrasts in the economic development and the present character of the industries and agriculture of the northern and southern sectors of Central Germany, the whole area has a large measure of unity through the commercial interdependence of its parts.

Lignite traffic.[1]—Central Germany produces nearly a half of the production of Germany's brown coal (Thuringia–Saxony 35 per cent., Upper Lusatia 5·0 per cent., Brunswick–Magdeburg 5·0 per cent.), whereas Lower Lusatia supplies just over a fifth, and the Province of Rhineland, west of Cologne, just over a quarter.

The brown coal deposits underlying the rich agricultural plains of loess soils in the Leipzig Bay form a north–south oval-shaped area with Leipzig at its centre, extending 40 kilometres from east to west through Leipzig and 70–80 kilometres from north to south with many outliers on the western edge. The limits of the field are marked by the following towns: Halle, Dessau, Bitterfeld, Eilenburg, Borna, Altenburg, Zeitz, Merseburg. The chief producing areas, on the other hand, lie near these towns on the periphery of the field. A second smaller field forms a long narrow belt, running north-west–south-east, in the foreland of the Harz Mountains with its chief centre in the extreme north-west in Helmstedt. In the State of Saxony, Zwickau, Lugau–Oelsnitz, and Freital (south-west of Dresden) produce the small amount of 4,000,000 tons of coal per year.

Brown coal is clearly the basis of modern industry in Central Germany, and it is in consequence the bulkiest commodity in its traffic by rail. Taking the returns from the five official traffic districts,[2] brown coal makes up 27 per cent. (about one-third with hard coal) of the traffic of Magdeburg–Anhalt, 41 per cent. (with hard coal, nearly a half) of Merseburg–Erfurt, and about a third (40 per cent. with hard coal) in each of Thuringia, Saxony, and Leipzig. The radius of profitable marketing of brown coal briquettes is 30–80 kilometres (though with the development of coal tar distillation, brown coal in the form of coke can now be marketed over a radius of 250 kilometres).

The trade in brown coal fuel is localized and over two-thirds of the total traffic in brown coal of each of the five trade districts (including *in* and *out* traffic, but excluding *local* traffic, *i.e.* hauls within the district) is transacted

[1] Figures are for 1927–28.

[2] These are the official districts used for railway traffic returns. They are: *Regierungsbezirk* Magdeburg and *Land* Anhalt; *Regb.* Merseburg and *Regb.* Erfurt; Thuringia; *Land* Saxony; and Leipzig district. See Thormann and Staab, p. 75 for brown coal trade statistics.

with the other four.[1] This traffic, expressed in grand total as the sum of the three: *in*, *out*, and *local* traffic, is dominated by Merseburg–Erfurt, which, out of a total traffic of 13,000,000 tons, exported 9,000,000 tons with a local traffic of nearly 4,000,000 tons. Saxony (*Land*), on the other hand, is mainly a receiver of brown coal, taking 5,250,000 tons, with a local and out traffic of about 2,000,000 tons each. As regards receipts and despatches for each district, both for coal and lignite, Central Germany, considered as these five traffic districts, is an almost closed province to the extent of 70 per cent. of its traffic. The trade of Lower Lusatia in lignite and its products (notably electricity), is dominantly with Brandenburg, and especially with Berlin.

Foodstuffs.—The traffic in agricultural products is of special importance in determining the commercial unity of an area which is so highly urbanized in one part and such a highly productive agricultural area in the other. In grain, Magdeburg–Anhalt alone has an export surplus. Saxony is an overwhelming importer. Apart from the latter, the other trade provinces are able to draw over half of their requirements from each other.[2] As regards livestock, Central Germany is not nearly such a closely-knit unit. The proportion of the inter-district to total (Reich) traffic reaches 19 per cent. for pigs, 36 per cent. for cattle, and 38 per cent. for sheep and goats. The district with the largest trade with the five districts of Central Germany, *i.e.* with over 50 per cent. in each category, is Merseburg–Erfurt, followed by Leipzig. Supplies are drawn from neighbouring districts, but pigs in particular, come from Schleswig-Holstein and East Prussia.

Total rail traffic by districts.—The distribution of the total trade of the five traffic districts of Central Germany with each other and with the other districts of Germany (over forty in number), is given below as a percentage of

Table 3. *Percentage of total goods traffic by rail in tons in* 1926 (*in and out*), *excluding foreign trade and local traffic* [3]

To and from the trade districts	*Magdeburg–Anhalt*	*Merseburg–Erfurt*	*Thuringia*	*Saxony*	*Leipzig*
Magdeburg–Anhalt	—	16·7	2·4	4·5	4·4
Merseburg–Erfurt	32·0	—	27·7	19·4	22·1
Thuringia	2·2	13·4	—	15·5	10·7
Saxony	6·8	15·2	25·3	—	37·2
Leipzig	1·7	4·4	4·5	9·6	—
Central Germany ..	42·7	49·7	59·9	49·0	74·4 [4]
Ruhr	8·4	8·0	6·5	2·6	4·4
Bavaria	1·6	4·5	10·5	5·8	2·7
Hannover	21·6	10·2	2·2	2·5	2·2
Silesia	3·7	4·2	2·3	15·7	4·3
Brandenburg–Berlin	10·0	8·3	3·9	13·9	4·1

[1] Thormann and Staab, p. 75.
[2] Thormann and Staab, p. 139.
[3] From Thormann and Staab, p. 160.
[4] For 1935 the corresponding figures were 45·4, 48·6, 56·6, 46·0, 74·7.

their total traffic in 1926. From this table it will be clear that the Magdeburg–Anhalt district in the north has close ties with the Merseburg–Erfurt belt to the south of it, to the extent of one-third of its total traffic, but otherwise its ties with the other districts of Central Germany are small, and it is closely allied with both the Hannover district to the west and Brandenburg–Berlin to the east. Just over a half of the total traffic by rail of these five districts is with each other, the remainder being widely distributed over the rest of Germany.

These districts, with the exception of Leipzig, are large, and obscure the trade to neighbouring districts on their borders. In this respect attention is drawn to the relatively densely peopled industrial districts in which Central Germany tapers out to the north-west, south-east, and south-west. The inclusion of the northern Harz Foreland, a distinct sub-region, in Central Germany is supported by the features of relief and natural vegetation, as well as of present economic structure. Nevertheless, the whole of this district, though clearly separated geographically from Braunschweig (the town), has close economic relations with it; moreover, it forms in part a detached part of the State of Brunswick. All students are agreed that Braunschweig itself should be excluded from the Mitteldeutschland complex and included with Niedersachsen. The Hof cotton-manufacturing district in Upper Franconia, though it lies on the south side of the Thuringian uplands, is at the extremity of the populous belt which runs west-south-west–east-north-east to Chemnitz, and is closely allied with Central Germany as well as with the south German textile area. The Görlitz district in Silesia and the Zwittau district in the extreme corner of Saxony are similarly transitional to Silesia, though beyond them, as in the Hof district, there is a definite break in the density of population and industry. Lower Lusatia, though a lignite-producing area, with important glass, textile, and electricity industries, contrasts in many ways with Central Germany, and is far more closely allied to the Berlin area and Brandenburg than with Central Germany. Here the Brandenburg frontier may conveniently be taken as marking the boundary zone of Central Germany.

Traffic routes.—These are shown on the maps in the Atlas of 'Landesplanung im Engeren Mitteldeutschen Industriebezirk.' The Elbe itself is the only deep, navigable river and it borders the north of the area. It is now continued westwards by the Mittelland canal, which joins the Elbe a few miles below Magdeburg. The Elbe takes barges of 1000 tons up to Magdeburg and up to 600 tons upstream to the frontier. The Mittelland canal is designed to take 1000-ton barges. In the whole of Central Germany south of this waterway there is at present only one navigable route, the Saale, on which barges up to 400 tons can reach Halle, and of 170 tons to a few miles above Naumburg. Otherwise, the whole of Central Germany depends entirely upon rail and road transport for the movement of both its bulky materials and its smaller consignments of manufactured foods.[1] Magdeburg is the great river port for northern Central Germany. There are also several important ports above it on the south bank of the river, which are transhipment points for goods coming up and down the Elbe and from the heavy industrial area in their immediate hinterland (salt, lignite, fertilizers). The chief of these are

[1] Canals are planned to link Gera and Leuna to Leipzig and Torgau, and the Saale is to be canalized to link Merseburg (Leuna) with the Mittelland canal.

Schönebeck, Barby, Aken, and Wallwitzhafen (Dessau). In this stretch of the Elbe, the bigger towns are Dessau, the capital of Anhalt, and Wittenberg, both of which have varied industries, with metal and machinery industries dominant in the first (headquarters of the Junkers aircraft works) and the chemical industry in the second.

Railway traffic, both in goods and passengers, includes local and through traffic, and owing to the position of Central Germany, through traffic is of particular importance. Omitting the latter, the close network of routes in the heart of the area as against the northern lowlands to the north and the uplands of the Weser–Fulda uplands to the west is a main feature. There are several outstanding passenger routes, which swell in density near the big cities as local traffic increases. Passenger traffic is shown on the map in the Atlas of 'Landesplanung' by bands along the railway proportional in width to the average daily gross tonnage of passenger trains in the summer of 1928. Leipzig, Halle, Chemnitz, Dresden, and Magdeburg are outstanding focal points of passenger traffic.[1] There is a continuous belt of high density of passenger traffic along the main Dresden–Hof line and its numerous small feeders from the towns of the Erzgebirge and Upper Lusatia. A main feature of the route pattern in the heart of Central Germany is the way in which the routes branch from the north–south route from Hannover to Kassel through Thuringia and north of the Harz, to converge on Halle and Leipzig, from whence they radiate southwards between Plauen and Dresden.

Goods traffic is also shown in the Atlas by bands along the railways for a daily average in the summer of 1928, showing the daily gross weight of goods trains, and the net tonnage carried, in both directions. There is no single focus, though Leipzig–Halle stands out as the chief area.[2] As regards the local traffic, there is a heavy traffic in lignite between Lower Lusatia and Berlin, with empty trucks coming back on the return journey. In Central Germany, lignite and fertilizers dominate the traffic. This is evident in the many short haul routes, as for example the Geiseltal which serves the Leuna works at its exit in the Saale valley a few miles distant. Briquettes also swell the traffic on both local and long-distance routes, *e.g.* Plauen–Hof, Magdeburg–Stendal–Hamburg, and Nørtheim–Hannover. There is also a heavy traffic in fertilizers, stone, and earths, *e.g.* on the Nordhausen–Halle route.

Road traffic is shown on a separate map which brings out very clearly the high density of traffic and the close network of roads in the triangular area from its base on the Saxony frontier to the Magdeburg–Braunschweig apex, and the open net in the more thinly peopled districts of the lowlands to the north, and Thuringia and the Weser basin to the west. Most remarkable is the high density of routes, with high traffic loads in the whole of the Erzgebirge

[1] The following four main routes are especially important: the Berlin–Hannover route via Stendal and Magdeburg skirts the north of Central Germany; the Hannover–Kassel route in the Leine valley, running south to Frankfurt, skirts the west of the area; the Berlin–Halle–Leipzig–Erfurt–Kassel route through to Frankfurt; and a branch route through Leipzig–Plauen–Hof to Munich.

[2] Routes with greatest tonnage are those which carry bituminous coal: from the Ruhr through Hannover to Berlin to the north of Central Germany; and via Ottbergen–Northeim–Nordhausen to Halle; and from Silesia via Kottbus to Berlin and via Kottbus and Torgau to Leipzig and Halle.

extending from Upper Lusatia to Plauen and Hof in the west, and in the area extending northwards through Leipzig and Halle around the north of the Harz to Braunschweig. There is an even spacing of small towns as local route centres in Thuringia at about 30 km. apart, with Erfurt as the dominant centre. Short routes serve the uplands of Thüringerwald. Several through routes stand out clearly, especially those from Berlin to Magdeburg, and via Wittenberg to Leipzig–Halle.

Many studies have been undertaken to determine the character and extent of the geographical unit of Mitteldeutschland in the middle Elbe basin. As might be expected there is a considerable difference of definition according to the particular criteria upon which they are based. All students of the problem however are agreed that there are several distinct units in the area and that these are, owing to their great contrasts, essentially interdependent and have shared in large measure a common historical and economic development. The units suggested fall into two categories. The smaller arise from the sharp contrasts in the area, the larger from the recognition that the interdependence of its parts is the main claim for the whole to be regarded as one unit. The question of the exact area, be it a whole or a part, to which the name *Mitteldeutschland* shall be given is a detail. The essential fact is that in the framework of the middle Elbe basin in Germany there are several clearly defined and strongly contrasted physical and economic units, which in virtue of their common trends of historical development and their close commercial interrelations to-day are to be considered as one major human region in the heart of Germany.

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There is an extensive literature on the subject of Mitteldeutschland, but many of the publications are not available in this country. Special reference may be made to the following:

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WEATHER AND VOLCANIC ACTIVITY ON KILIMANJARO

LIEUT. P. C. SPINK, R.N.V.R.

WE have received from Lieutenant P. C. Spink accounts of two ascents of Mount Kilimanjaro. His description of the glaciers in the crater has already been published in the *Quarterly Journal* of the Royal Meteorological Society for October 1943. The following account therefore deals with the meteorological results and volcanic activity only.

Kilimanjaro consists of two important peaks joined by a long saddle: the ice-capped volcanic crater of Kibo (19,700 feet), the highest point in Africa, and her sister mountain, Mawenzi (17,560 feet), an extinct volcano of very jagged and fantastic shape, virtually bare of ice and permanent snow and volcanologically older than Kibo. The area covered by these mountains is very extensive: it is estimated at some 40 square miles in area over 16,000 feet. There are three huts for climbers, the highest being the Kibo Hut, lying under the Kibo massif at 16,300 feet.

The first expedition which I accompanied started on 28 January 1943 and reached the summit on February 1. It consisted of three Europeans with some twenty porters carrying equipment and four rain-gauges. These were installed respectiveiy at 7150 feet in a gap of the rain forest, at 9420 feet above the forest belt, at 12,400 feet in the heathery open country, and at 16,400 feet on the lava scree just below the Kilimanjaro massif. This last gauge is one of the highest in the world, and is firmly embedded in the scree. A native guide has been chosen to take monthly measurements.

We were fortunate that the weather was variable after installing the first three gauges, and thus we had an opportunity of measuring the rainfall on the return journey. We found that the rainfall progressively increased as we descended, and the ratios of these three gauges in descending order were respectively 8·25 : 15·5 : 27·5, suggesting that the forest belt at lower levels has the greatest rainfall when it is general.

A thunderstorm occurred while we were encamped on the saddle between Mawenzi and Kibo at about 15,000 feet. This storm began at 1200 hours and lasted until 1500 hours, during which time the air temperature fell from 41° to 31° F. in about twenty minutes. When the storm cleared, Mawenzi was covered in new snow and presented a fine sight. At about 1800 hours we observed heavy cumulo-nimbus clouds approaching the saddle from both the north-east and the south-west; the resulting convergence caused a renewal of the snow, which continued intermittently until about 0200 hours the next morning. The snow was lying down to 14,000 feet and the saddle was covered with a 2-inch snowfall, very unusual at that time of year. At 0715 hours the air temperature was 28·4° and the snow surface 20° F.

Psychrometric readings were taken twice daily, and when subsequently compared with tephigrams taken on the same date and in the same air mass the moisture content was found to agree substantially. Up to the 13,000-foot level the dry-bulb temperature in the early morning on the mountain was lower than that of the corresponding free air temperature, due no doubt to

Phot. 803 Squadron R.N.A.S., Tanga

Kibo from the south. Ratzel Glacier in foreground, Ash Pit area immediately south of the North Glacier in background. July 1943. (The horizontal line through the Ratzel Glacier is due to a defect in the photograph)

Phot. 803 Squadron R.N.A.S., Tanga

Kibo from the north-east. Ratzel Glacier on the left, North Glacier in foreground. Note lack of snow in Ash Pit area to south of North Glacier. Mount Meru in extreme left background. July 1943

Phot. P. R. O. Bally

Kibo photographed from the saddle at 14,500 feet

Phot. P. R. O. Bally

Kibo crater from Gillman's Point, showing disintegrating ice. Ice dome on right; 500-foot rock wall below Kaiser Wilhelm Spitze on left

Phot. P. R. O. Bally

Kibo crater from Leopard's Point. Note lamination of disintegrating ice by vertical sun

radiation. At the mid-day reading the reverse was the case, temperatures being higher than those of the free air. Above 15,000 feet free air readings were consistently lower than dry-bulb mountain readings, both morning and evening.

No very low temperatures were recorded, the lowest ground readings being only 20° F. at 16,300 feet. The summit temperature was as high as 37° at 1500 hours. The lowest humidity measured was 39 per cent. at 16,000 feet at 0800 hours. It was noticeable as we ascended above the 15,000-foot level that the wind backed to the north, and on the summit it appeared to be from the north or north-north-west (Force 2); the direction was confirmed by the pilot balloon ascents for that season of the year. A katabatic wind from the Kibo glaciers began at about 2100–2200 hours; at times it reached Force 5 or 6.

Many climbers of Kilimanjaro have pronounced the crater to be dead. The first, Dr. Hans Meyer, remarked that there was no trace of fumaroles in the Ash Pit area in 1888, though he was of the opinion that there must be some warmth which was keeping large deposits of snow from accumulating; and in 1888 the snow masses on Kibo, particularly in the outer crater, were considerably greater than at the present time. As recently as July 1942 a visitor to the Ash Pit reported seeing only one active fumarole, and that was on the south-east side of the Ash Pit itself. He saw sulphur beds, but made no examination of them.

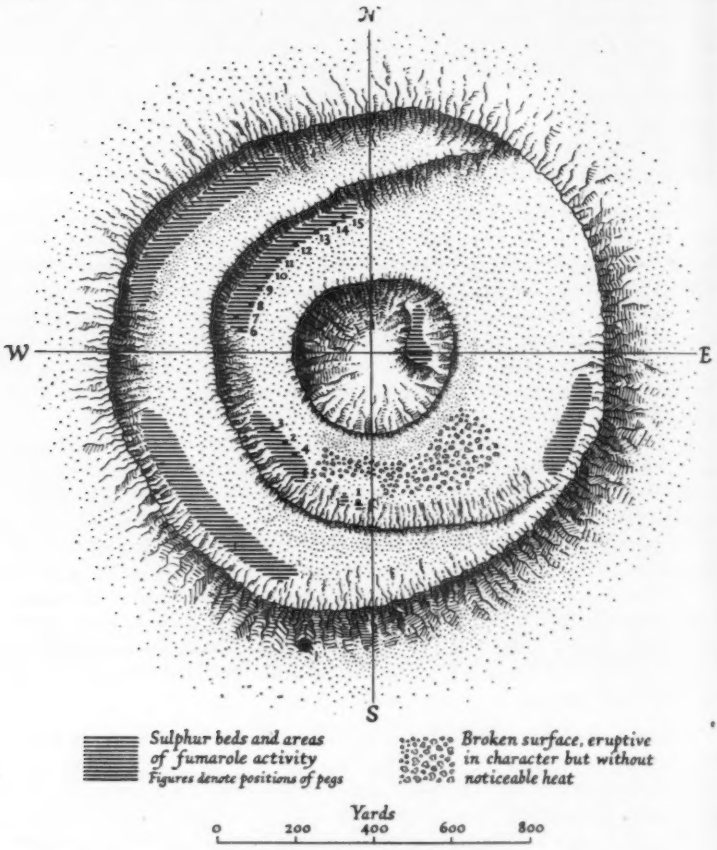
On my first ascent of the Kaiser Wilhelm Spitze, when nearly 2 miles from the Ash Pit I could smell sulphur wafted across the crater by a light northerly wind. A volcanologist, Mr. J. J. Richards, who made a simultaneous visit to the Ash Pit, reported an increase of activity since his visit of a few months before. Air photographs taken some ten years ago show much snow lying in the Ash Pit area, and covering places which are now extensive hot sulphur beds. One concludes that the increase in activity is very recent. Air photographs taken in July 1943 emphasize the present lack of snow in those areas, and to some degree in the main crater where the ice masses are being steadily reduced by vertical insolation, intense evaporation, and smaller precipitation than in former years.

In view of the interest taken in the reports of activity in the crater of Kibo, I decided to see for myself exactly what degree of activity there is and to make a general survey. Equipped with a rope, high-temperature thermometers, and a series of numbered wooden pegs, and in the company of two excellent guides, the brothers Sambonanga and Kimatare, the second expedition reached the true crater, or Ash Pit, at noon on 18 July 1943, under perfect weather conditions.

The Ash Pit, which lies in the north-westerly part of Kibo, is obviously of recent origin: it has sharp, well-preserved edges and steep walls. It is almost perfectly circular and about 400 yards in diameter and 400 feet in depth. It is almost ringed round by a circular and higher bank 150 yards away, which in its turn is completely ringed by yet another bank, considerably higher.

We approached from the south side, and the first signs of activity were apparent at the inside foot of the inner bank, where a large yellow patch on

the dark lava floor proved to be two fumaroles emitting a sulphurous gas, with a high water-vapour content and a temperature of 144° F. Our Peg 1 was inserted at this point. We then observed that high up on the same bank, but about 300 or 400 yards to the east, was a huge sulphur deposit with many smoking fumaroles, the fumes from which were streaming up and over the



Kibo crater: The Ash Pit

top, subsequently being wafted southwards, which accounted for a sulphurous smell noticed on the way across from Gillman's Point.

Taking the whole crater area as a circle, and dividing it into quadrants, there was almost a continuous line of gaseous fumaroles in their sulphur beds, running along the base of, and extending in many instances almost to the top of, the inner circular bank from the centre of the S.W. to the full extent of the N.W. Quadrant where they abruptly ceased. Pegs 2, 3, 4, and 5

were inserted along the S.W. Quadrant beds, and Pegs 6–15 now mark the extent of the N.W. Quadrant beds. The temperatures of the fumarole gases were in every case, but one, higher than those of the first pair examined, the average being as high as 172° F. The one exception was No. 2 fumarole, which had a temperature of 140° F., and this may have been an error, due to the thermometer not being pushed far enough into the vent.

The N.E. Quadrant appeared free from sulphur deposits and fumaroles, with the exception of the Ash Pit itself where a conspicuous abutment of rock jutting some way into the pit had numbers of fumaroles smoking away on the surface, which was yellow with sulphur. The S.E. Quadrant contained the very active lines of fumaroles high up on the inner circular bank referred to earlier. These appeared to be the most active of any seen during the day, and I regret that, on account of fatigue and recurring mountain sickness, I had neither the time nor inclination to visit that interesting area or the remainder of the outer circle banks.

On the high banks of the third or outer circle, the S.W. Quadrant showed most activity, with large sulphur beds and smoking lines of fumaroles which extended, after a gap of some hundreds of yards, into the N.W. Quadrant, which however did not appear to be so active as the S.W. and S.E. Quadrants. The N.E. Quadrant showed no activity.

The Ash Pit was circumnavigated, but except for the one area of activity which has been mentioned, no fumaroles were seen. There was even a very light sprinkling of snow lying in the shadow of the northern wall, which extended two-thirds of the distance to the bottom. Only one or two other small patches of snow were to be seen in the crater, and these were lying in the quiescent area between the Ash Pit and inner circle on the S.E. side.

Standing on the Ash Pit rim, and surveying the area generally, I noticed that with the exception of the eastern side, the general colour of the inner and outer circular banks was yellow, or had a yellow tinge. Each fumarole mouth had its deposit of crystalline sulphur of almost 100 per cent. purity. Water condensed on the thermometer each time it was inserted into a vent hole, and the surrounding ground was damp, warm, and very soft in places, so that on one occasion I sank up to the knees with each step, much to the worry of the native guides, who thought that I was tempting Lucifer too much. The newly broken surface revealed sub-surface fumaroles not yet reaching through to the surface. On the return journey up the southern inner bank very small isolated sulphur deposits were noticed, and upon probing were found to contain small fumaroles, each with a high temperature. These seem suggestive of increasing activity. The fumaroles ran generally in parallel lines along the banks, and their gases were not dangerous. Only once was a smell other than sulphur noted, and then it was a very pungent acrid smell, but again with no ill effects. In the area between the south side of the inner circle and the Ash Pit proper the surface was studded with little circular eruptive areas, but cold and apparently dead.

As snow cover in the active areas is now physically impossible, it should be easy for future investigators to find the numbered pegs with which I tried to demarcate the active areas in the S.W. and N.W. Quadrants and to record any further increase of activity in the crater of Kibo.

DRODSKY'S CAVE

E. J. WAYLAND

SURPRISINGLY situated among sand-dunes and extinct rivers in Ngamiland, not far from the border of South-West Africa, is a group of remarkable intercommunicating caverns here collectively styled Drodsky's Cave because, it is claimed, they were discovered by Mr. M. Drodsky when conducting a party of wealthy travellers in 1932. According to Drodsky, these caverns form part of a series of caves and natural galleries which had another quite different entrance some forty years ago, to which he was directed by Bushman information; but an earthquake (mentioned later in this account) closed the former entrance and opened the present one. This is not impossible.

Magnetic bearings, and a compass traverse, place the cave more or less at a point 67 miles along a bearing of 263° (true) from a spot 14 miles south of Nokanen on the Tsau Road, so that its approximate coordinates are S. 20° 2′, E. 21° 25′. The cave is situated in the westernmost of two rocky hills near the right bank of the permanently dry Khnihabe river (Kihabedum of the maps) and the entrances (one small, the other wide) which face north-west are near the junction of a pediment-like slope and the more abrupt rise of the naked limestone rocks. The limestone is highly crystalline and metamorphic; it is very far from being pure calcium carbonate, and its intimate association with quartz in several places suggests that the noticeably high specific gravity of this rock is due to the development of wollastonite, while the clayey portions of the limestone have combined with the magnesium present to produce spinel. Pure limestone, $CaCo_3$, has specific gravity 2·71; wollastonite, $CaO.SiO_2$, 2·8–2·9; and spinel, $MgO.Al_2O_3$, 3·5–4·1. The rock is almost certainly of great age, and probably belongs to the Basement Complex of Africa (Swaziland system). Exteriorily it weathers into grikes, knife-edges, and points of unpleasant sharpness, thus recalling karstland features; and climbing over it one is painfully reminded of the Pleistocene coral country of north-east Zanzibar.

The full extent of the caverns is unknown, for it may be safely anticipated that the clearance of cave-earth and other deposits would reveal chambers additional to the main three and their subsidiaries, now accessible. These three chambers are each of the order of 80 yards in length, while their breadths are perhaps one-third of this. The entrance chamber and the second chamber, behind it, are oriented along 40°, unlike the third and innermost, the major axis of which runs along 170° (approximately).

From the entrance, naturally concealed by rocks until one is right upon it, one scrambles down a steep slope of fallen rock and other debris to the general floor-level of the entrance cave, which is above that of the laterally situated second chamber, which, in its turn, lies higher than the floor of the third and innermost cavern. It is tempting to give these chambers fanciful names, such as The Barons Hall, Westminster Abbey, and the Hall of Pillars. I shall here content myself however with calling them C1, C2, and C3, as numbered from the entrance inwards.

In addition to the main caves there is a number of subsidiary openings of various sorts, most of which are more or less blocked. It is likely that one or more of these may lead to other big chambers. This is true of both ends of C1, particularly the left end as one faces the cave, C2, and the east side of C3, from the south-east corner of which an opening leads to a narrow cave with a kind of swallow-hole at its southern end. The floors of C1 and C2 are irregular and are partly of stone and partly of cave deposit. C3 however is remarkably level, and consists of little more than cave deposit, except at the mouth of a subsidiary cave on the left (E) of the entrance, where there is a mound of very fine-grained, quite unbleached, Kalahari sand, redder than the somewhat coarser sand to be found outside the cave. It may well have been blown in when this chamber connected with the exterior, if at any time it did so. The cave-earth itself appears to be very thick in places and to be a mixture of the usual residues from the solution of crystalline limestone with the equally usual remains of beetles and other insects, together with a little blown sand which has, from time to time, entered from the outside.

There would appear to be a levelling influence at work in the cave-earth, particularly in C3, for at the far end of this cavern there is an accumulation of leopard's dung, all of which is old but not extremely so; yet the accompanying spoor which must at no remote time have patterned the floor has been completely smoothed out. Not only so, but here, as in other places where it occurs in these caverns, the cave-earth is beautifully flat and level, like the surface of a billiard table, except where it inclines gently upwards into small subsidiary caves, and one can hardly doubt that the levelling and smoothing are effects of a single process, the clue to which is provided by the one true exception to this planation: the pile of red sand already mentioned. The red sand is typical, fine-grained, wind-sorted, rounded and polished desert sand. Nearly all the grains are quartz with a thin coating of iron oxide. Beetle wing-cases and similar remains are markedly absent from this sand, while the cave-earth is rich in such organic material. It is also "crawling" with live organisms resembling woodlice, beetles, and other relatively lowly members of a cave fauna. They are completely missing from the red sand, which clearly has no attractions for them. On the other hand, these small creatures are constantly fossicking in the cave-earth and turning it over, thus inadvertently smoothing out what to them are major irregularities (leopard's spoor for example), and gradually rendering the whole surface flatter and flatter, and keeping it flat.

Leopards still inhabit the cave, but nowadays they live nearer the entrance. Two of their lairs were found, and on returning from the interior of the cave to the entrance chamber on one occasion we found fresh leopard's spoor over our own.

Stalactites and stalagmites are very numerous and well developed. All the usual patterns and types are present, and in places the coloration is good. It is not proposed to describe them in detail; it will be sufficient here to note that the stalactites which adorn the remarkably high dome and topsides of C2 are particularly beautiful, while C3 has a surprising number of massive crystalline pillars, some of which reach 5 feet or more in thickness. The lower parts of all these pillars are buried to an unknown depth in cave-earth, so that they rise abruptly, without any apparent spread-out bases, from the

flat floor to a height of 20–25 feet, and some of the columns, owing to the coalescence of adjacent stalactites, are fluted. This cavern impressively recalls some of the many-pillared temples of ancient Egypt: the Hypostyle Hall in the temple city of Karnak, for example.

A noticeable and interesting feature of many of these columns, and of columns in general throughout the cave, is that they are split horizontally at about 5 feet above present ground level, thus producing gaps of an inch or so in width. Several of the gaps have been filled by later deposits of carbonate of lime, but the scars are still evident. Clearly this severance has resulted from a vertical pull operative in all three chambers; moreover the surface change displayed by the many horizontal fracture surfaces appear to be identical in kind and in degree, thus indicating close contemporaneity of fracturing. What is the significance of this? We are told that at the beginning of this century a severe earthquake shook Ngamiland; could this have caused the columns to break? Obviously it could, but the mode of propagation of earthquake waves is well known, and they are most unlikely to have produced any such effect. The only available alternative appears to be gravity. That is to say the columns appear to have broken under their own weight; which could have happened only if the support beneath them had failed.

That the rocky floor of the cave could have subsided without the superstructure is unthinkable, but what alternative remains? Just this: there is plenty of evidence in the cave to show that there have been different periods of cave-earth and stalactite formation, and that large stalagmites have been built up on thick beds of cave-earth, and it is likely enough that the columns of C_3 are so based. Now the very presence of this cave among sand-dunes and dead rivers is in itself indicative of climatic change, and there is abundant evidence of similar changes in other parts of Ngamiland; it is by no means impossible therefore that these cracked columns tell the same sort of story, for all that is needed to produce the fractures is a volume reduction in the lower cave-earth upon which the bases of the columns presumably rest. Such reduction would be consequent upon a drying-out of the cave-earth during a period of aridity, when, too, the unbleached Kalahari sand might have been blown into the cave.

Nowadays the cave is quite dry and, except for a very few small tubes which may be ignored, none of the stalactites and stalagmites is growing. All are dead and many are dusty, but of little basins which in pre- or inter-arid days held water crystal clear, and doubtless cold, there is evidence in plenty. Even the stalactites and stalagmites display zoned sections, suggestive of periodic change comparable with that revealed by the study of the annual rings of trees; but how far this resemblance results, if at all, from growth-rate changes climatically engendered not only in the living plant but also in the unliving crystal aggregate as well remains to be discovered.

No trace of Bushman paintings and none of human occupation were found in the cave. What may lie beneath the cave-earth we do not know, but it is perhaps significant that no stone-age remains of any sort were found either inside the cave or in the surrounding country. It should be remarked however that there is a tendency in Ngamiland for the earlier Stone-Age relics to be buried, like the Palaeoliths of the Botletle river and of the ancient extension

of Lake Ngami at Toteng for example. Apart from the fallen stalactites near the entrance, whose collapse is easily understood and the truncated nature of many of the small stalactites high up on the roof of C1, not easily understood, the cave has a very untouched appearance, and because of its extreme inaccessibility to any one except the Bushmen, a wandering people who, on account of superstitious fears, will not go up into the hills, Drodsky's claim that the cave has been unvisited since he and his associates in adventure peeped into it eleven years ago is seemingly correct.

Drodsky's half century or so of close and friendly association with the Bushmen and their peculiar ways, together with his great knowledge of their country and language were guarantee enough, one would suppose, for a safe and easy journey. Accordingly Mrs. Drodsky and her two children were allowed to accompany the party, the other two members of which were Mr. W. Cairns (the acting District Commissioner, Ngamiland) and myself. Contrary to expectation however we are unlikely to forget the struggles involved in a protracted and nearly abortive attempt to reach the cave, which we explored on Christmas Day 1943.

It is now declared a Monument, for purposes of protection (Bechuanaland Protectorate Proclamation No. 68 of 1934, addition to).

REVIEWS

POLAR REGIONS

IGLOO FOR THE NIGHT. By Mrs. TOM MANNING. *London: Hodder and Stoughton*, 1943. 8×5½ *inches; 232 pages; illustrations and end-paper sketch-map.* 12*s* 6*d*

For a straightforward account of a first-rate Arctic journey it would be difficult to improve upon Mrs. Manning's book. If anything, it is too modest because the dangers and difficulties which they encountered are scarcely mentioned, and the impression is given that Arctic travel is a much simpler matter than is actually the case, even with such a competent and experienced traveller as Tom Manning.

Mrs. Manning had had no experience of the North when she and her husband left Cape Dorset in the fall of 1938 on a journey by whale-boat and dog-team that was to last two-and-a-half years and take them through the least-known part of the Canadian Arctic. 'Igloo for the night' is her personal account of their travels along the bleak shores of Foxe Basin and of her learning to live in these strange surroundings. It is written in a simple style well suited to the subject and the account of the winter journey to Cape Dorset in Chapter 12 is particularly effective. The geographical discoveries of the expedition are not described in detail, but this is not the purpose of the work and they have been fully dealt with by Mr. Manning in the *Geographical Journal* for May–June 1943.

For the most part the Mannings travelled alone, so there is little about the Eskimos and, as Mrs. Manning did not learn the language, her impressions of them are at first rather superficial. On the journey to Cape Dorset however she learns to appreciate their unfailing courtesy and kindliness and there is a charming description of her reception at the native camp at Iggarakshuk.

The war-time quality of paper and the binding does not do the book full justice, but the unusual interest of the account fully compensates for any shortcomings in its appearance. G. W. R.

AUSTRALASIAN ANTARCTIC EXPEDITION, 1911–14. GEOGRAphical narrative and cartography. Scientific Reports, Series A, vol. I. By DOUGLAS MAWSON. *Sydney: A. H. Pettifer*, 1942. 12×9½ *inches; 364 pages; illustrations, sketch-maps, and folding-maps.* £3 17*s* 6*d*

This volume (a report on Macquarie Island, Series A, volume I), is the last but one of a formidable list of reports of the Australasian Antarctic Expedition 1911–14. The usual lack of funds with which most expeditions have to contend and the outbreak of the 1914 World War at the end of the expedition were two obstacles which would have prevented many men from attempting a task that must at times have seemed well-nigh impossible. But perhaps to the man with the will and temerity to haul his sledge over 100 miles by himself back to his base after the loss of his two companions, Ninnis and Mertz, it meant no more than unavoidable delay of certain success. With no fewer than fifteen professional scientists on his staff, the expedition's results are of the highest importance. Sir Douglas Mawson has done perhaps more than any other man to unveil the secrets of Antarctica.

This large volume, which has been so long awaited, is divided into two sections: a Narrative of 298 pages and Cartography of 30 pages. The Narrative contains the Log of S.Y. *Aurora*; Operations and exploration of the Main Base Party; Activities of the Western Base Party; and Proceedings at Macquarie

Island. It has of course been anticipated both by 'The home of the blizzard,' 1915, and by Captain J. K. Davis' 'With the *Aurora* in the Antarctica,' 1919. Now we have in the official record a detailed and straightforward account of the expedition's work set out in historical retrospect, and extremely readable. There appear to be some misreferences in the text to the numbers of the plates, and in some cases text and captions seem at variance. It is not always clear whether bearings given are true or magnetic. It would have been better to have followed the standard practice of giving bearings in degrees from 360° when true is meant and bearings from Cardinal Points when magnetic. The maps given include Queen Mary Land, King George Land, Adélie Land, and the Charnockite Coast east of Commonwealth Bay, a large-scale plan of the surroundings of the Expedition's base at Cape Denison, and several track charts of the voyages of *Aurora*.

The second section of the book deals with the survey and cartography in detail. There is a gazetteer of all place-names with notes on the character of each feature and the origin of the name; a point which future surveyors might well remember to incorporate in their reports. The plates, and there are 124 of them, are arranged together at the end of the book, preceded by a section of detailed description of each one. Furthermore, not only is the name of the photographer given, but also the reference numbers of each negative. The negatives, original records, and maps are preserved in the Mitchell Library, and the natural history collections and relics at the Australian Museum.

A complete list of the ninety-one scientific reports of the 1911–14 Expedition, which have so far been published by the Government Printing Offices of Adelaide and Sydney, is printed on the covers of this volume under review. In order to limit the cost of printing, the reports on birds, mammals, and some invertebrates, general discussion on Antarctic geology and glaciology, and two volumes of summary and discussion of meteorological observations are to be incorporated with like subjects in the reports now being printed of the British Australia New Zealand Antarctic Research Expedition 1929–31.

Thus, with the small exception mentioned, which will be published shortly, Sir Douglas Mawson has brought to a close a most successful expedition, for the end should not be (as too often unfortunately it is) until the final results of men's striving and endurance in the field are in a form which can be preserved for posterity. Sir Douglas is to be congratulated upon a work of great magnitude and importance which has few peers in its presentation. Q. R.

GENERAL

REGIONAL PLANNING: an outline of the scientific data relating to planning in Great Britain. By L. B. Escritt. *London: George Allen and Unwin*, 1943. 9 × 5½ *inches; 264 pages; maps and diagrams.* 12*s* 6*d*

This book, in many respects a pioneer study, has the disadvantage of being written by a single author trying to cover the numerous facets of a rapidly expanding subject. To-day, governmental organization of regional planning and the building up of specialist teams drawn from those with geographical as well as from those with architectural, engineering, and kindred trainings, result in an enrichment of the planner's outlook. It is as an introduction to other aspects that Mr. Escritt's book will prove most useful.

This volume is most detailed on the water-supply and sewerage problems of towns, on which topics the author is on ground within his own training. On some other aspects of planning the reviewer feels more could have been made

and also that the approach is slightly too academic in view of the fact that planning in Britain is bound to take the form of redevelopment with considerable conservation, for at least one more generation, of many existing features. One premise taken for granted in the book is that there will be full location control of factory and other buildings. While it is greatly to be hoped that such may be the case it seems unlikely to come about with the existing economic structure of industry and land ownership. Meanwhile it is essential that local authorities, as well as planners, should know what is a desirable target and how to aim at it, and this volume will help in this respect.

A number of blemishes mar the text, and it is hoped these will be removed in a later edition. On p. 18 reference is made to the Scott Report having suggested the publication of a 2½-inches-to-the-mile map; it should be realized that this is now available for local authorities working on a regional scheme. Reference is made (p. 39) to the local authority having information about National Monuments; for this the Ancient Monuments Commission should be consulted as they are responsible for the systematic collection of this information. The use of the term "hachure lines" for rulings (p. 50) is unfortunate in view of its cartographic use.

In chapter 4 Mr. Escritt gives some notes on the education of the planner. Here one feels the position of geography is not fully realized since in a tentative syllabus it appears only under "Economics: commercial geography." It is true that much of what would appear in a University curriculum for a geography course is entered under "Regional surveying." Geography has a strong claim to have a say in national planning.

Finally, a most valuable feature is the comprehensive bibliography, and this helps forward the avowed function of the book: "to give, in mere outline, the more exact and better understood of the sciences that relate to town planning and their interconnection one with another" (p. 13). A. C. O.

STING-FISH AND SEAFARER. By H. Muir Evans. *London: Faber and Faber*, 1943. 9×5½ *inches; 180 pages; illustrations. 15s*

This work deals with a subject of which but little is known: the poisonous effects of the sharp spines with which very many fishes of various unrelated groups are armed. The author is a surgeon and a naturalist and has spent many years in practice at Lowestoft, where he had many opportunities of coming across injuries caused to fishermen in the course of their calling. He has also voyaged widely and has studied the effects of such wounds in various waters from the Channel and Mediterranean to Madagascar and Mauritius.

The wounds, or stings as he calls them, are caused by specially developed spines found in many fishes. These are most often the front spine of the dorsal fin but are sometimes found elsewhere, as on the gill covers or by the side of the vent.

On the English coasts the Weevers of the genus *Trachinus* are well known for their stinging habits, and an excellent description of the structure of the poison organ is given illustrated by sections of the spine and its accompanying glandular tissue, where the poison is formed, and by muscular action forced into the wound. The wounds caused by all these fishes are excruciatingly painful and cause an acute stabbing pain and inflammation of the part affected. As a rule the pain can be much alleviated by the application of a solution of permanganate of potassium which, of course, is often used in the case of snake bite. Dr. Evans states however that such wounds are rarely fatal.

Chapters are devoted to the Sting-ray, with its formidable serrated spine on the tail, the Spiny Dogfish which play havoc among the herrings round our

coasts, and may other less familiar forms. The Mediterranean Mureana Eel has always been much dreaded, but in this case it is from its bite though there has also been some doubt about its poisonous action. Finally there is a chapter on the fishes with electric organs of which there are several examples in addition to the so-called Electric Eel of the rivers of South America; this however is not a true eel but a catfish of the family *Siluridae*. Altogether the volume, though not of any direct geographical interest, contains much interesting matter though perhaps somewhat discursive and repetitive in style. It is very well illustrated with good figures of most of the fishes mentioned and microscopic sections to illustrate the structure of the poison spines. W. L. S.

DESERT JOURNEY. By GEORGE RODGER. *London: Cresset Press*, 1944. $9\frac{1}{2} \times 6$ *inches; 152 pages; illustrations and end-paper sketch-maps. 15s*

Among the many books written by war correspondents, 'Desert journey' is remarkable for two things. First, the author arrives too late for the first two battles, instead of just happening to be there at the right moment quite without arranging it, and thereby wins sympathy. And second, he drives across Africa from Douala to Massawa.

The author was given a roving assignment for *Life Magazine*. In 1940 he left England for the Cameroons to photograph the activities of the Free French Forces in the territories which had recently broken away from Vichy. After considerable difficulty he finally met General de Larminat and got permission to photograph Colonel Leclerc's forces which were about to attack Kufra. As there were no planes available he left Douala in company with a French interpreter, the Baron, and two chrevrolets. After driving through Fort Lamy, Faya, Ounianga, and Sarra, the so-called Mission de Reportage arrived at Kufra only to find that Colonel Leclerc's forces had already taken the oasis. Hearing that Free French troops were moving from the Cameroons to Eritrea, the Mission cut straight across from Faya to Abéché to meet this column which was going to join up with the Brigade de L'Orient. Deciding that the column, which they met at Adré, was moving too slowly, the Mission went on to El Fasher and then to Khartoum. Owing to difficulties and delays, partly caused by the Baron, the author arrived too late to photograph the capture of Keren, but was present at the taking over of Asmara and Massawa.

The second half of the book deals with the Syrian and Iranian campaigns and with visits to India and Transjordania. This latter part is interesting and well told, but has not the special interest of the car journey. Although at the time many journeys more remarkable than this 3000-mile drive were made by men of the Long Range Desert Group and the Fighting French Forces under Colonel Leclerc, they were well equipped and trained for desert driving. The author and the Baron mostly picked up their knowledge on the way, and had only a little wire-netting instead of proper sandmats.

'Desert journey' is an entertaining and well-written book. It contains much of interest about all the campaigns mentioned and a good picture of the different countries. The photographs are, as is to be expected, excellent. Had it not been for an official muddle there might have been some films of the prisoners at Kufra and Colonel Leclerc's forces, but these were all destroyed by bad developing, so the long desert journey was almost wasted. However in this book it is all turned to good account and the author was later rewarded by taking the first pictures of the meeting of the British and Russian forces in Iran. It is unfortunate that even in Ethiopia and Libya place-names are given in the French form, perhaps because the author was attached to the Free French.

D. R. C.

THE MONTHLY RECORD

OIL IN THE MACKENZIE VALLEY

A paper by Mr. Trevor Lloyd in the *Geographical Review*, vol. 34, No. 2, 1944, gives a most interesting account of the Canol project now nearing fulfilment in the Northwest Territories and Yukon, by the army of the United States. The oil of the Mackenzie basin is to supply the Alaska Highway by a pipeline to pump the crude oil from Norman Wells, on the right bank of the Mackenzie, to a refinery at Whitehorse on the Highway, at the head of the 100-mile railway from Skagway.

To Norman Wells from Waterways, the railhead in Alberta on the Athabaska river, is 868 miles by air and 1170 by water. The Athabaska river is winding and shallow, and the lake windswept. The Slave river section from Chipewyan to Fort Resolution is interrupted at Fitzgerald by a 16-mile portage to avoid the rapids. The 100 miles along the southern shore of Great Slave Lake are ice-bound long after the Mackenzie river is open, and stormy in the brief summer season of three months; the Mackenzie is broad and swift. A fleet of lighters was constructed at Waterways, while the U.S. Corps of Engineers made rafts from pontoons to be pushed down the rivers and across the lakes by small speedboats. By this route, with its inconvenient break at the Fitzgerald–Fort Smith portage, 9000 tons of 4-inch steel pipe, and immense amounts of oil drilling machinery and stores were transported to Norman Wells.

The route for the pipeline to Whitehorse was largely over unknown country until it was photographed by the Canadian Air Force in 1942. For 15 miles it follows the deep canyon of the Carcajou river, where the canyon bottom is "fairly free from water in summer and winter." In spring the road and the pipeline will be submerged. The line rises from a few hundred feet at Norman Wells to 4500 at the Christie Pass and will require ten pumping stations, to be supplied, except for oil, by the road of some 550 miles between Norman Wells and Whitehorse. From the refinery here pipelines have been laid to Skagway, and along the Alaska Highway. The refinery alone will cost twenty-four million dollars, and the whole enterprise was estimated in November last at one hundred and thirty-four million. But it is expected to provide for that part of the world very cheap aviation spirit, motor gasoline, and heavy fuel oil.

This account of a dramatic achievement, to be completed this summer, is full of interesting detail and admirably illustrated.

THE TURKISH GEOGRAPHICAL SOCIETY

We have pleasure in recording the foundation in 1941 at Ankara of the Turkish Geographical Society. In 1942 the Society began to publish a journal, *Türk Coğrafyâ Dergisi*, the first two numbers of which we have received through the British Council. The journal, well produced with illustrations and maps, is printed in the roman character, and for most of the principal articles there are summaries in a European language. Its scope is wide, though, in these two numbers, physical geography and climatology predominate. As much of the recent literature on the geography of Turkey is not accessible to British students, this periodical is welcome as an aid to a fuller knowledge of the Republic.

Among the papers the following may be noted. Professor Ardel contributes two geomorphological studies, on the origin of the littoral platforms around Trabzon, the three lower which occur below 120 metres being attributed to marine abrasion, and on the structure of the south-west Marmara region. He

considers that the characteristic basins are not the result of faulting and folding, but of epeirogenetic movements and erosion. P. Ullyott and O. Ilgaz publish the first of a series of studies on the Bosphorus, in which present hydrographical knowledge is summarized, with a criticism of the Merz-Moller theory of the currents. A short account is given of the severe earthquakes which occurred between November 21 and December 20 in the Kizil Irmak basin and the valley of the Kelkit Çay, when more than five hundred lives were lost. The epicentres of these earthquakes occurred along the great crustal fracture extending from Amasya to Erzincan. Dr. S. Selen discusses the economic self-sufficiency of the Republic, and stresses the necessity for developing the home market. Owing to past concentration on tobacco, cotton, and other crops for export in the coastal plains, the production of food is relatively low; to expand the cultivated area, which amounts only to 1 square kilometre per 140 inhabitants, much land improvement is necessary. The recent development of communications is already stimulating the interchange of domestic products.

THE NOMOGRAPH

In the *Geographical Review*, vol. 33, No. 4, 1943, Mr. Richard Edes Harrison has an interesting brief paper on The Nomograph as an Instrument in Map Making: the nomograph being defined as a graphical device for plotting great circle routes and distances on azimuthal, conical, and cylindrical map projections. If one has a map on a stereographic polar or oblique projection, one can use the corresponding equatorial graticule to set out great circles and measure distances in degrees on either of the former: on the principle of the well-known diagram published in 1885 by Commander C. D. Sigsbee, U.S.N., which has been widely used. Mr. Harrison applies the same method to the orthographic, zenithal equidistant, and gnomonic projections, with a worked example of the first. He would apply it also to conical and cylindrical projections, but confines his examples to the zenithal. Readers of the *Geographical Journal* will be familiar with the process for the Mercator projections, normal or oblique, but we do not remember to have seen it used for a conical projection, and it would be useful if the author could at some convenient time extend his note to include the conical class. There can be no doubt that the method is very useful for sketching oblique great circles, which are not usually wanted with any high precision in planning, since the creation of landing grounds and supplies and traffic too often require deviations from a strict great circle. But there are certain limiting considerations. The nomograph must be on precisely the scale of the map to which it is applied; and the map must have the world outline accurately drawn, which is laborious for zenithal projections trying to cover the whole world, since the antipodal point of the zenith is the bounding circle of the map, and distortion in that neighbourhood is enormous. Mr. Harrison would have his nomograph drawn precisely for each degree, and this refinement would greatly increase the accuracy with which the intermediate great circles could be sketched. But it is not so certain that even with a one-degree nomograph it would be possible to construct an oblique projection of the same class that would look more than a sketch: so small a divergence from geometrical accuracy is so sadly conspicuous in a projection. It would be most interesting to try, and one may hope that when the author has constructed a one-degree nomograph on an adequate scale, and a world map of the same scale on which to practice it, he will be able to make copies available to students, for there is much to be learned in this art. One may find in the end that the best way to make a zenithal world-map on a desired centre is to derive it from a set of oblique Mercators and their transverse graticule or nomograph.

MAX DEMOREST

In the *Transactions* of the American Geophysical Union for 1943, Mr. François Matthes has written a memorial to Max Demorest, the American glaciologist, who was killed in an accident on the Greenland Ice Cap on 30 November 1942. The details of the accident have only recently been published. Demorest was one of the most outstanding of young glacial geologists in the United States. In 1930 he accompanied the Fourth Greenland Expedition of the University of Michigan, and in 1932 and 1933 he was glaciologist and assistant meteorologist on the Pan-American Airways Greenland Expedition. He has published several important papers on ice movement, and when he was called up for service with the American Air Corps he was studying the effects of deformation on ice crystals with a specially adapted polarizing microscope. His work confirmed and extended the results of the 1938 British Jungfraujoch expedition.

Because of his knowledge of Greenland he was sent there by the Army Air Corps in 1942. On 9 November 1942 a Flying Fortress crashed on the ice cap not far from where Demorest was stationed. The weather at the time prevented attempts at rescue, but food was dropped to the survivors by plane. On November 29 Demorest and an American staff-sergeant, with two motor sledges, tried to reach the wrecked plane to bring back the survivors. Leaving the motor sledges a short distance away, they went on skis to the plane; Demorest doctored the cases of frostbite and they then went back to fetch the motor sledges. When within 100 yards of the plane, Demorest, who was leading, suddenly disappeared with his sledge into a crevasse. The crew of the plane tried to reach him with ropes but without success. The surviving airmen were rescued in the end, one hundred and forty-eight days after the crash.

MEETINGS: SESSION 1943–44

The following have been elected Fellows of the Society:

On April 3: Lieut. Donald William Boydell, R.E.; Major Count Anthony de Salis; Rev. Fred Elliott; Richard Alexander Hamilton; Roger M. P. Hartog, B.A.; John Edward Hicks; James Johnson; Dr. L. C. King; S. Wilson Kitchen; Miss Phyllis C. Langmead; Rev. David J. Laurie; Lieut.-Colonel the Rev. John C. W. Linsley, B.A.; Alfred Marshall, M.B.E.; Major the Rev. Theodore Pfeiffer, B.A., B.D.; Lieut.-Colonel the Rev. Edward A. Rein; Lieut.-Colonel A. B. Whatman, M.B.E., M.A., A.M.I.E.E., A.M.I.R.E.

Sixteenth Meeting, 24 April 1944. The President in the Chair

Geographical Films: The British Graham Land Expedition, 1934–37. With commentary by members of the Expedition